UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

RECEIVED

FEB 5

DEQ - WATER

Mr. Larry Lawson
Virginia Department of Environmental Quality
629 Main Street
Richmond, VA 23219

Re: Middle Fork Holston TMDLs, Washington County

Dear Mr. Lawson:

The Environmental Protection Agency (EPA) Region III, is pleased to approve the Middle Fork Holston TMDLs. These TMDLs were submitted for EPA review on January 04, 2001. The TMDLs for Cedar Creek, Hall/Byers Creek, and Hutton Creek were established and submitted in accordance with section 303 (d)(1)(c) and (2) of the Clean Water Act. These TMDLs were established to address an impairment of water quality as identified in Virginia's 1998 Section 303 (d) list. Virginia identified the impairment for these water quality-limited segments within the Middle Fork Holston watershed based on exceedances of the fecal coliform water quality standard.

In accordance with Federal Regulations in 40 CFR §130.7, a TMDL must be designed to meet water quality standards, and (1) include, as appropriate wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, (2) consider the impacts of background pollutant contributions, (3) take critical stream conditions into account (the conditions when water quality is most likely to be violated), (4) consider seasonal variations, (5) include a margin of safety (which accounts for uncertainties in the relationship between pollutant loads and instream water quality), and be subject to public participation. The enclosure to this letter describes how the TMDLs for Cedar Creek, Hall/Byers Creek, and Hutton Creek satisfy each of these requirements.

Following the approval of these TMDLs, Virginia shall incorporate them into the Water Quality Management Plan pursuant to 40 CFR § 130.7(d)(2). As you know, any new or revised National Pollutant Discharge Eliminations Systems (NPDES) permit must be consistent with the TMDLs Waste Load Allocation pursuant to 40 CFR §122.44 (d)(1)(vii)(B). Please submit all such permits to EPA for review as per EPA's letter dated October 1, 1998.

In order for these TMDLs to fulfill the Commonwealth's 2000 commitments, all of the impairments must be addressed. Cedar Creek, Hall/Byers Creek, and Hutton Creek were all listed on the 1998 303(d) list as having a benthic impairment. The Commonwealth has notified EPA of its intentions of delist these streams for their benthic impairments. EPA is requesting a copy of the Tennessee Valley Authority data assessing the benthic community of these stream segments.

Sincerely,

Rebecca Hanmer, Director for
Water Protection Division

Enclosure

Decision Rationale

Total Maximum Daily Load of
Fecal Coliform for Cedar Creek

I. Introduction

This document will set forth the Environmental Protection Agency's (EPA) rationale for approving the Total Maximum Daily Load (TMDL) of Fecal Coliform for Cedar Creek submitted for final Agency review on January 04, 2001. Our rationale is based on the TMDL submittal document to determine if the TMDL meets the following 8 regulatory conditions pursuant to 40 CFR §130.

1. The TMDLs are designed to implement applicable water quality standards.
2. The TMDLs include a total allowable load as well as individual waste load allocations and load allocations.
3. The TMDLs consider the impacts of background pollutant contributions.
4. The TMDLs consider critical environmental conditions.
5. The TMDLs consider seasonal environmental variations.
6. The TMDLs include a margin of safety.
7. The TMDLs have been subject to public participation.
8. There is reasonable assurance that the TMDLs can be met.

II. Background

Located in Washington County, Virginia, the overall Cedar Creek watershed [1] is approximately 7.3 square miles. The TMDL addresses 5.24 miles of stream from the headwaters of Cedar Creek to its confluence with the Middle Fork Holston. Pasture is the primary land use in the watershed. Cedar Creek is a tributary to the Middle Fork Holston which flows from southern Virginia to Tennessee.

In response to Section 303 (d) of the Clean Water Act (CWA), the Virginia Department of Environmental Quality (VADEQ) listed 5.24 miles of Cedar Creek as being impaired by elevated levels of fecal coliform on Virginia's 1998 303 (d) list. Cedar Creek was listed for violations of Virginia's fecal coliform bacteria standard for primary contact. Fecal Coliform is a bacterium which can be found within the intestinal tract of all warm blooded animals. Therefore, fecal coliform can be found in the fecal wastes of all warm blooded animals. Fecal coliform in itself is not a pathogenic organism. However, fecal coliform indicates the presence of fecal wastes and the potential for the existence of other pathogenic bacteria. The higher concentrations of fecal coliform indicate the elevated likelihood of increased pathogenic organisms. Cedar Creek identified as watershed VAS-O05R, was given a high priority for TMDL development. Section 303 (d) of the Clean Water Act and its implementing regulations require a TMDL to be developed for those waterbodies identified as impaired by the State where technology-based and other controls do not provide for the attainment of Water Quality

[1] The Cedar Creek watershed is part of Middle Fork Holston hydrologic unit (No. 2070005)

Standards. The TMDL submitted by Virginia is designed to determine the acceptable load of fecal coliform which can be delivered to Cedar Creek, as demonstrated by the Hydrologic Simulation Program Fortran (HSPF)[2], in order to ensure that the water quality standard is attained and maintained. HSPF is considered an appropriate model to analyze this watershed because of its dynamic ability to simulate both watershed loading and receiving water quality over a wide range of conditions.

The TMDL analysis allocates the application/deposition of fecal coliform to land based and instream sources. For land based sources, the HSPF model accounts for the buildup and washoff of pollutants from these areas. Buildup (accumulation) refers to all of the complex spectrum of dry-weather processes that deposit or remove pollutants between storms.[3] Washoff is the removal of fecal coliform which occurs as a result of runoff associated with storm events. These two processes allow the HSPF model to determine the amount of fecal coliform reaching the stream from land based sources. Point sources and wastes deposited directly to the stream were treated as direct deposits. These wastes do not need a transport mechanism to allow them to reach the stream. The allocation plan calls for the reduction in fecal coliform wastes delivered by cattle in-stream and septic systems. The waste load allocation in Table 1 is given as a daily load. In order to determine the annual waste load allocation, please multiply the WLA by 365 days. The annual WLA for the Cedar Creek watershed is 1.55E+10 cfu/year. This value is the summation of the waste load allocations for Dillows Shop and Car Wash and Meadowview Elementary School.

Table #1 summarizes the specific elements of the TMDL.

Parameter	TMDL(cfu/yr)	*WLA*[1] (cfu/day)	LA(cfu/yr)	*MOS*[2] (cfu/yr)
Fecal Coliform	6.07×10^{14}	4.25×10^{07}	5.77×10^{14}	3.04×10^{13}

1 The WLA is given as a daily load.
2 Virginia includes an implicit MOS by identifying the TMDL target as achieving the total fecal coliform water quality concentration of 190 cfu/100ml as opposed to the WQS of 200 cfu/ml. This can be viewed explicitly as a 5% MOS.

The United States Fish and Wildlife Service has been provided with a copy of this TMDL.

III. Discussion of Regulatory Conditions

EPA finds that Virginia has provided sufficient information to meet all of the 8 basic requirements for establishing a fecal coliform TMDL for Cedar Creek. EPA is approving the Cedar Creek TMDL. Our approval is outlined according to the regulatory requirements listed below.

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[2]Bicknell, B.R., J.C. Imhoff, J.L. Little, and R.C. Johanson. 1993. Hydrologic Simulation Program-FORTRAN (HSPF): User's Manual for release 10.0. EPA 600/3-84-066. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.
[3]CH2MHILL, 2000. Fecal Coliform TMDL Development for Cedar, Hall, Byers, and Hutton Creeks Virginia,

1) The TMDL is designed to meet the applicable water quality standards.

Virginia has indicated that excessive levels of fecal coliform due to nonpoint sources (directly deposited into the Creek) have caused violations of the water quality standard and designated use on Cedar Creek. The water quality criterion for fecal coliform is a geometric mean 200 cfu (colony forming units)/100ml or an instantaneous standard of no more than 1,000 cfu/100ml. Two or more samples over a 30-day period are required for the geometric mean standard. Most of the streams monitored by Virginia are sampled once in a 30-day period. Therefore, most violations of the State's water quality standard are due to violations of the instantaneous standard (1,000 cfu/100 ml).

The HSPF model was used to model the fecal coliform loading to the stream. The model determined the amount of fecal coliform reaching the stream from both point and nonpoint sources. The following discussion is intended to describe how controls on the loading of fecal coliform to Cedar Creek will ensure that the criterion is attained.

The TMDL modelers determined the fecal coliform production rates within the watershed. Information was attained from a wide array of sources on the farm practices in the area (land application rates of manure), the amount and concentration of farm animals, point sources in the watershed, animal access to the stream, wildlife in the watershed and their fecal production rates, land uses, weather, stream geometry, etc. This information was put into the model. The modelers also assigned values to several parameters that affect the transport of fecal coliform to the stream. The modelers adjusted the parameters to insure a correspondence between observed and simulated conditions.

The hydrology component of the model for all the Middle Fork Holston TMDLs (Cedar, Byers, Hutton, and Hall Creeks) was developed based on Groseclose Creek and then transferred to each individual watershed. This was done because there were no stream gages on the other waters. Groseclose Creek which is a similar watershed located just upstream from Cedar Creek, Hall/Byers Creek, and Hutton Creek. When the simulated data on Groseclose accurately reflected the observed flow data the model was considered complete and transferred to the other watersheds. The hydrologic parameters were adjusted to match the conditions in each watershed. The model was calibrated by comparing simulated flow results to the nine instantaneous flow samples obtained from each of the impaired waters.

EPA believes that using HSPF to model and allocate fecal coliform will ensure that the designated use and water quality standards will be attained and maintained for Cedar Creek.

2) The TMDL includes a total allowable load as well as individual waste load allocations and load allocations.

<u>Total Allowable Loads</u>

Virginia indicates that the total allowable load of fecal coliform is the sum of the loads allocated to land based, precipitation driven nonpoint source areas (impervious areas, built-up area, distributed area, field crop, forest, hayfield, improved pasture, overgrazed pasture, poor pasture, row crop, strip crop), directly deposited nonpoint sources of fecal coliform (cattle in-stream and failed septic systems), and point sources (Dillows Shop and Car Wash and Meadowview Elementary School). Activities such as the application of manure, fertilizer, and the direct deposition of wastes from grazing animals are considered fluxes to the land use categories. The actual value for the total fecal load can be found in Table 1 of this document. The total allowable load is calculated on an annual basis due to the nature of HSPF model.

Waste Load Allocations

Virginia has stated that there are two point sources discharging to Cedar Creek, Dillows Shop and Car Wash and Meadowview Elementary School. EPA regulations require that an approvable TMDL include individual WLAs for each point source. According to 40 CFR 122.44(d)(1)(vii)(B), "Effluent limits developed to protect a narrative water quality criterion, a numeric water quality criterion, or both, are consistent with assumptions and requirements of any available WLA for the discharge prepared by the State and approved by EPA pursuant to 40 CFR 130.7." Furthermore, EPA has authority to object to the issuance of any NPDES permit that is inconsistent with the WLAs established for that point source. During the sampling sweep event conducted in December of 1999 the Meadowview Elementary School effluent had fecal coliform concentrations above its permitted values. DEQ will be investigating this facility to insure that it is in compliance with the permit. The allocation plan for this watershed did not call for any reduction from either of the point sources. The point source loading was based on the permitted flow and fecal concentration. Table 2 illustrates the loading associated with these point sources. Table 2 illustrates the daily loading from these point sources in order to determine the annual loading, simply multiply the load by 365 days. The annual load for Dillows Shop and Car Wash and Meadowview Elementary School is 9.96E+9 and 5.51E+9 cfu/year respectively.

Table 2 - Summarizes the WLAs for each point source

Point Source Name	Existing Load(cfu/day)	Allocated Load(cfu/day)	Percent Reduction
Dillows Shop and Car Wash	2.73E+07	2.73E+07	0%
Meadowview Elementary School	1.51E+07	1.51E+07	0%

Load Allocations

According to federal regulations at 40 CFR 130.2 (g), load allocations are best estimates of the loading, which may range form reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading. Wherever possible natural and nonpoint source loads should be distinguished.

In order to accurately simulate landscape processes and nonpoint source loadings, VA DEQ used the HSPF model to represent the Cedar Creek watershed. The HSPF model is a comprehensive modeling system for simulation of watershed hydrology, point and nonpoint loadings, and receiving water quality for conventional pollutants and toxicant[4]. More specifically HSPF uses precipitation data for continuous and storm even simulation to determine total fecal loading to Cedar Creek from impervious areas, built-up area, distributed area, field crop, forest, hayfield, improved pasture, overgrazed pasture, poor pasture, row crop, strip crop. The total land loading of fecal coliform is the result of the application of manure, direct deposition from cattle and wildlife (geese and deer) to the land, fecal coliform production from dogs, and best management practices which have already been implemented on several farms reduce the loading of fecal coliform and sediment to streams.

In addition, VADEQ recognizes the significant loading of fecal coliform from cattle in-stream and failed septic systems. These two sources are not dependent on a transport mechanism to reach a surface waterbody and therefore can impact water quality during low and high flow events.

It should be noted that an extensive amount of BMPs (Best Management Practices) have been implemented within Cedar Creek , Hall/Byers Creek, and Hutton Creek. BMPs have been installed in approximately 25% of the Cedar Creek watershed. Based on the model these BMPs have reduced the fecal coliform loading by 15.6%.

There are three weather stations in the area around the study area. The closest weather station (Helton, NC) had a significantly larger annual rainfall average (53 inches) than the watershed in question. It was decided that the use of this watershed would bias the model toward regulating nonpoint sources (runoff related wastes) and was therefore not used. The study area had a mean annual rainfall of 43 inches. Weather stations in Bristol and Wytheville were used because their mean annual rainfall (41 and 39 inches respectively) was closer to the annual rainfall of the study area. The watershed is located halfway between these weather stations. DEQ averaged the rainfall data from these two stations and applied the computed data to the model. This interpretation can affect the model because there maybe some differences between the actual storm event and the computed event. Table 3 illustrates the load allocation for the land application of fecal coliform.

Table 3 - Load allocation for the land application of fecal coliform

Source	Existing Load(cfu/yr)	Allocated Load(cfu/yr)	Percent Reduction
Impervious Areas	3.02E+13	3.02E+13	0%
Built-up Area	1.06E+12	1.06E+12	0%
Distributed Area	6.02E+09	6.02E+09	0%
Field Crop	8.01E+11	8.01E+11	0%
Forest	3.9E+11	3.9E+11	0%
Hayfield	4.38E+12	4.38E+12	0%

[4] Supra, footnote 2.

Improved Pasture	1.55E+14	1.55E+14	0%
Overgrazed Pasture	2.51E+14	2.51E+14	0%
Poor Pasture	1.11E+14	1.11E+14	0%
Row Crop	1.29E+13	1.29E+13	0%
Strip Crop	9.58E+12	9.58E+12	0%
Failed Septic Systems	8.1E+11	5.67E+09	98.5
Cattle In-Stream	3.64E+13	2.55E+11	98.5

3) The TMDL considers the impacts of background pollution.

Fecal coliform loads from deer and geese were considered background loading and were incorporated into the model. These sources had a fecal coliform loading rate of cfu/acre/day.

4) The TMDL considers critical environmental conditions.

EPA regulations at 40 CFR 130.7 (c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of Cedar Creek is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards[5]. Critical conditions are a combination of environmental factors (e.g., flow, temperature, etc.), which have an acceptably low frequency of occurrence but when modeled to, insure that water quality standards will be met for the remainder of conditions. In specifying critical conditions in the waterbody, an attempt is made to use a reasonable "worst-case" scenario condition. For example, stream analysis often uses a low-flow (7Q10) design condition because the ability of the waterbody to assimilate pollutants without exhibiting adverse impacts is at a minimum. Virginia's standards are designed to be applied during all flow events.

The sources of bacteria for these stream segments were a mixture of dry (direct sources) and wet (nonpoint loads) weather driven sources. Since the watershed is not dominated by one type of loading, there may be no single condition that is protective for all other conditions. The critical condition for Cedar Creek was represented as a typical hydrologic year, with both dry and wet periods.

5) The TMDLs consider seasonal environmental variations.

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[5]EPA memorandum regarding EPA Actions to Support High Quality TMDLs from Robert H. Wayland III, Director, Office of Wetlands, Oceans, and Watersheds to the Regional Management Division Directors, August 9, 1999.

4.4×10^8

Seasonal variations involve changes in stream flow as a result of hydrologic and climatological patterns. In the continental United States, seasonally high flow normally occurs during the colder period of winter and in early spring from snow melt and spring rain, while seasonally low flow typically occurs during the warmer summer and early fall drought periods. Consistent with our discussion regarding critical conditions, the HSPF model and TMDL analysis will effectively consider seasonal environmental variations.

6) *The TMDLs include a margin of safety.*

This requirement is intended to add a level of safety to the modeling process to account for any uncertainty. Margins of safety may be implicit, built into the modeling process by using conservative modeling assumptions, or explicit, taken as a percentage of the wasteload allocation, load allocation, or TMDL.

Virginia includes an explicit margin of safety by establishing the TMDL target water quality concentration for fecal coliform at 190 cfu/ 100mL, which is more stringent than Virginia's water quality standard of 200 cfu/100 mL. This would be considered an explicit 5% margin of safety.

7) The TMDLs have been subject to public participation.

This TMDL was subject to a number of public meetings. Three public meetings were held in Glade Spring. The meetings were held on November 09, 1999, January 27, 2000, and March, 2000 and were intended to address initial questions and concerns regarding outreach issues and the TMDL process.

The first public meeting was held on November 9, 1999 in Glade Spring and was announced in the Washington County News on October 27, 1999 and the Virginia Register on November 08, 1999. The second public meeting was announced in the Virginia Register on December 28, 1999, the Washington County News on January 19, 2000, and the Bristol Herald Courier on January 23, 2000. The March 30, 2000, public meeting was announced in the March 13, 2000 Virginia Register and the local papers. No written comments or responses were provided by VA DEQ with this submission.

8) There is a reasonable assurance that the TMDL can be met.

EPA requires that there be a reasonable assurance that the TMDL can be implemented. WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source.

Nonpoint source controls to achieve LAs can be implemented through a number of existing programs such as Section 319 of the Clean Water Act, commonly referred to as the Nonpoint Source Program. Additionally, Virginia's Unified Watershed Assessment, an element of the Clean Water Action Plan, could provide assistance in implementing this TMDL.

Decision Rationale

**Total Maximum Daily Load of
Fecal Coliform for Byers Creek and Hall Creek**

I. Introduction

This document will set forth the Environmental Protection Agency's (EPA) rationale for approving the Total Maximum Daily Load (TMDL) of Fecal Coliform for Hall Creek and Byers Creek submitted for final Agency review on January 04, 2001 Our rationale is based on the TMDL submittal document to determine if the TMDL meets the following 8 regulatory conditions pursuant to 40 CFR §130.

1. The TMDLs are designed to implement applicable water quality standards.
2. The TMDLs include a total allowable load as well as individual waste load allocations and load allocations.
3. The TMDLs consider the impacts of background pollutant contributions.
4. The TMDLs consider critical environmental conditions.
5. The TMDLs consider seasonal environmental variations.
6. The TMDLs include a margin of safety.
7. The TMDLs have been subject to public participation.
8. There is reasonable assurance that the TMDLs can be met.

II. Background

Located in Washington County, Virginia, the overall Byers/Hall Creek watershed[1] is approximately 15.7 square miles. The TMDL addresses 5.87 miles of Hall Creek, from its headwaters to its confluence with Byers Creek, and 1.19 miles of stream from the confluence with Hall Creek to its confluence with the Middle Fork Holston. The Middle Fork Holston flows from southern Virginia to Tennessee.

In response to Section 303 (d) of the Clean Water Act (CWA), the Virginia Department of Environmental Quality (VADEQ) listed 1.19 miles of Byers Creek and 5.87 of Hall Creek as being impaired by elevated levels of fecal coliform on Virginia's 1998 303 (d) list. Hall and Byers Creek were both listed for violations of Virginia's fecal coliform bacteria standard for primary contact. These Creeks were listed as being benthically impaired as well. Fecal Coliform is a bacterium which can be found within the intestinal tract of all warm blooded animals. Therefore, fecal coliform can be found in the fecal wastes of all warm blooded animals. Fecal coliform in itself is not a pathogenic organism. However, fecal coliform indicates the presence of fecal wastes and the potential for the existence of other pathogenic bacteria. The higher concentrations of fecal coliform indicate the elevated likelihood

[1]The Hall/Byers Creek watershed is part of Middle Fork Holston hydrologic unit (No. 2070005)

of increased pathogenic organisms. Byers Creek identified as watershed VAS-O05R, was given a high priority for TMDL development. Hall Creek identified as watershed VAS-O05 was given a high priority as well. Section 303 (d) of the Clean Water Act and its implementing regulations require a TMDL to be developed for those waterbodies identified as impaired by the State where technology-based and other controls do not provide for the attainment of Water Quality Standards. The TMDL submitted by Virginia is designed to determine the acceptable load of fecal coliform which can be delivered to Byers Creek and Hall Creek, as demonstrated by the Hydrologic Simulation Program Fortran (HSPF)[2], in order to ensure that the water quality standard is attained and maintained. These levels of fecal coliform will ensure that the Primary Contact usage is supported. HSPF is considered an appropriate model to analyze this watershed because of its dynamic ability to simulate both watershed loading and receiving water quality over a wide range of conditions.

The TMDL analysis allocates the application/deposition of fecal coliform to land based and instream sources. For land based sources, the HSPF model accounts for the buildup and washoff of pollutants from these areas. Buildup (accumulation) refers to all of the complex spectrum of dry-weather processes that deposit or remove pollutants between storms.[3] Washoff is the removal of fecal coliform which occurs as a result of runoff associated with storm events. These two processes allow the HSPF model to determine the amount of fecal coliform from land based sources which is reaching the stream. Point sources and wastes deposited directly to the stream were treated as direct deposits. These wastes do not need a transport mechanism to allow them to reach the stream. The allocation plan calls for the reduction in fecal coliform wastes delivered by cattle in-stream and septic systems. The waste load allocation in Table 1 is given as a daily load. In order to determine the annual waste load allocation, please multiply the WLA by 365 days. The annual waste load allocation for Hall/Byers Creek is 7.85E+10 cfu/year.

Table #1 summarizes the specific elements of the Hall/Byers Creek TMDL.

Parameter	TMDL(cfu/yr)	*WLA*[1] (cfu/day)	LA(cfu/yr)	*MOS*[2] (cfu/yr)
Fecal Coliform	1.03×10^{15}	2.15×10^{8}	9.83×10^{14}	5.17×10^{13}

1 This loading is a daily value. In order to determine the annual loading please multiply the WLA by 365 days which equals

2 Virginia includes an implicit MOS by identifying the TMDL target as achieving the total fecal coliform water quality concentration of 190 cfu/100ml as opposed to the WQS of 200 cfu/ml. This can be viewed explicitly as a 5% MOS.

The United States Fish and Wildlife Service has been provided with a copy of this TMDL.

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[2]Bicknell, B.R., J.C. Imhoff, J.L. Little, and R.C. Johanson. 1993. Hydrologic Simulation Program-FORTRAN (HSPF): User's Manual for release 10.0. EPA 600/3-84-066. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.

[3]CH2MHILL, 2000. Fecal Coliform TMDL Development for Cedar, Hall, Byers, and Hutton Creeks Virginia,

$7.85\, X 10^{10}$

III. Discussion of Regulatory Conditions

EPA finds that Virginia has provided sufficient information to meet all of the 8 basic requirements for establishing a fecal coliform TMDL for Hall and Byers Creek. EPA is therefore approving this TMDL. Our approval is outlined according to the regulatory requirements listed below.

1) The TMDL is designed to meet the applicable water quality standards.

Virginia has indicated that excessive levels of fecal coliform due to nonpoint sources (directly deposited into the Creek) have caused violations of the water quality standards and designated uses on Hall and Byers Creek. The water quality criterion for fecal coliform is a geometric mean 200 cfu (colony forming units)/100ml or an instantaneous standard of no more than 1,000 cfu/100ml. Two or more samples over a 30-day period are required for the geometric mean standard. Most of the streams monitored by Virginia are sampled once in a 30-day period. Therefore, most violations of the State's water quality standard are due to violations of the instantaneous standard.

The HSPF model is being used to determine the fecal coliform deposition rates to the land as well as loadings to the stream from point and other direct deposit sources necessary to support the fecal coliform water quality criterion and primary contact use. The following discussion is intended to describe how controls on the loading of fecal coliform to Hall and Byers Creek will ensure that the criterion is attained.

The TMDL modelers determined the fecal coliform production rates within the watershed. Information was attained from a wide array of sources on the farm practices in the area (land application rates of manure), the amount and concentration of farm animals, point sources in the watershed, animal access to the stream, wildlife in the watershed and their fecal production rates, land uses, weather, stream geometry, etc. This information was put into the model. The modelers also assigned values to several parameters that affect the transport of fecal coliform to the stream. The modelers adjusted the parameters to insure a correspondence between observed and simulated conditions

The hydrology component of the model for all the Middle Fork Holston TMDLs (Cedar, Byers, Hutton, and Hall Creeks) was developed based on Groseclose Creek and then transferred to each individual watershed. This was done because there were no stream gages on the other waters. Groseclose Creek which is a similar watershed located just upstream from Cedar Creek, Hall/Byers Creek, and Hutton Creek. When the simulated data on Groseclose accurately reflected the observed flow data the model was considered complete and transferred to the other watersheds. The hydrologic parameters were adjusted to match the conditions in each watershed. The model was calibrated to the impaired watersheds (Cedar Creek, Hall/Byers Creek, and Hutton Creek) by comparing simulated flow results to observed flows (monthly samples).

EPA believes that using HSPF to model and allocate fecal coliform will ensure that the designated uses and water quality standards will be attained and maintained for Hall and Byers Creek.

2) The TMDL includes a total allowable load as well as individual waste load allocations and load allocations.

Total Allowable Loads

Virginia indicates that the total allowable load of fecal coliform is the sum of the loads allocated to land based, precipitation driven nonpoint source areas (impervious areas, built-up area, distributed area, field crop, forest, hayfield, improved pasture, overgrazed pasture, poor pasture, row crop, strip crop), directly deposited nonpoint sources of fecal coliform (cattle in-stream and failed septic systems), and point sources (Emory-Meadowview Waste Water Treatment Plant (WWTP)). Activities such as the application of manure, fertilizer, and the direct deposition of wastes from grazing animals are considered fluxes to the land use categories. The actual value for the total fecal load can be found in Table 1 of this document. The total allowable load is calculated on an annual basis due to the nature of HSPF model.

Waste Load Allocations

Virginia has stated that there is one point sources discharging to Hall Creek, Emory-Meadowview WWTP. EPA regulations require that an approvable TMDL include individual WLAs for each point source. According to 40 CFR 122.44(d)(1)(vii)(B), "Effluent limits developed to protect a narrative water quality criterion, a numeric water quality criterion, or both, are consistent with assumptions and requirements of any available WLA for the discharge prepared by the State and approved by EPA pursuant to 40 CFR 130.7." Furthermore, EPA has authority to object to the issuance of any NPDES permit that is inconsistent with the WLAs established for that point source. The allocation plan for this watershed did not call for any reductions from the point source. The Waste Load Allocation was determined by multiplying the permitted discharge concentration by the daily flow. It should be noted that due to treatment technology, the point source is likely to be discharging fecal coliform at concentrations below its permitted limit. Table 2 illustrates the loading associated with this point source. The values in Table 2 are equivalent to the daily load, in order to determine the annual load please multiply the values in Table 2 by 365 days. The annual loading from this point source is 7.85 +E10 cfu/year.

Table 2 - Summarizes the WLAs for each point source

Point Source Name	Existing Load (cfu/day)	Allocated Load (cfu/day)	Percent Reduction
Emory-Meadowview WWTP	$2.15x10^8$	$2.15x10^8$	0%

Load Allocations

According to federal regulations at 40 CFR 130.2 (g), load allocations are best estimates of the loading, which may range form reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading. Wherever possible natural and nonpoint source loads should be distinguished.

In order to accurately simulate landscape processes and nonpoint source loadings, VA DEQ used the HSPF model to represent the Hall/Byers Creek watershed. The HSPF model is a comprehensive modeling system for simulation of watershed hydrology, point and nonpoint loadings, and receiving water quality for conventional pollutants and toxicant[4]. More specifically HSPF uses precipitation data for continuous and storm event simulation to determine total fecal loading to Hall/Byers Creek from impervious areas, built-up area, distributed area, field crop, forest, hayfield, improved pasture, overgrazed pasture, poor pasture, row crop, strip crop. The total land loading of fecal coliform is the result of the application of manure, direct deposition from cattle and wildlife (geese and deer) to the land, fecal coliform production from dogs, and best management practices which have already been implemented on several farms reduce the loading of fecal coliform and sediment to streams.

In addition, VADEQ recognizes the significant loading of fecal coliform from cattle in-stream and failed septic systems. These two sources are not dependent on a transport mechanism to reach a surface waterbody and therefore can impact water quality during low and high flow events.

It should be noted that an extensive amount of BMPs (Best Management Practices) have been implemented within Cedar Creek , Hall/Byers Creek, and Hutton Creek. BMPs have been installed in approximately 20% of the Byers/Hall Creek watershed. Based on the model these BMPs have reduced the fecal coliform loading by 15.1%.

There are three weather stations in the area around the study area. The closest weather station (Helton, NC) had a significantly larger annual rainfall average (53 inches) than the watershed in question. It was decided that the use of this watershed would bias the model toward regulating nonpoint sources (runoff related wastes) and therefore not used. The study area had a mean annual rainfall of 43 inches. Weather stations in Bristol and Wytheville were used because their mean annual rainfall (41 and 39 inches respectively) was closer to the annual rainfall of the study area. The watershed is located halfway between these weather stations. DEQ averaged the rainfall data from these two stations and applied the computed data to the model. This interpretation can affect the model because there maybe some differences between the actual storm event and the computed event. Table 3 illustrates the load allocation for the land application of fecal coliform.

[4] Supra, footnote 2.

Table 3 - Load allocation for the land application of fecal coliform

Source	Existing Load (cfu/yr)	Allocated Load (cfu/yr)	Percent Reduction
Impervious Areas	6.75E+13	6.75E+13	0%
Built-up Area	2.43E+12	2.43E+12	0%
Field Crop	9.80E+11	9.80E+11	0%
Forest	1.73E+12	1.73E+12	0%
Hayfield	1.00E+13	1.00E+13	0%
Improved Pasture	2.94E+14	2.94E+14	0%
Overgrazed Pasture	4.37E+14	4.37E+14	0%
Poor Pasture	1.16E+14	1.16E+14	0%
Row Crop	4.55E+13	4.55E+13	0%
Strip Crop	6.20E+12	6.20E+12	0%
Failed Septic Systems	1.32E+12	2.11E+10	98.4
Cattle In-Stream	5.38E+13	8.61E+11	98.4

3) The TMDL considers the impacts of background pollution.

Fecal coliform loads from deer and geese were considered background loading and were incorporated into the model. These sources had a fecal coliform loading rate of cfu/acre/day.

4) The TMDL considers critical environmental conditions.

EPA regulations at 40 CFR 130.7 (c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of Hall/Byers Creek is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards[5]
. Critical conditions are a combination of environmental factors (e.g., flow, temperature, etc.), which have an acceptably low frequency of occurrence but when modeled to, insure that water quality

[5]EPA memorandum regarding EPA Actions to Support High Quality TMDLs from Robert H. Wayland III, Director, Office of Wetlands, Oceans, and Watersheds to the Regional Management Division Directors, August 9, 1999.

$4.4x10^8$

standards will be met for the remainder of conditions. In specifying critical conditions in the waterbody, an attempt is made to use a reasonable "worst-case" scenario condition. For example, stream analysis often uses a low-flow (7Q10) design condition because the ability of the waterbody to assimilate pollutants without exhibiting adverse impacts is at a minimum. Virginia's standards are designed to be applied during all flow events.

The sources of bacteria for these stream segments were a mixture of dry (direct sources) and wet (nonpoint loads) weather driven sources. Since the watershed is not dominated by one type of loading, there may be no single condition that is protective for all other conditions. The critical condition for Hall/Byers Creek was represented as a typical hydrologic year, with both dry and wet periods.

5) The TMDLs consider seasonal environmental variations.

Seasonal variations involve changes in stream flow as a result of hydrologic and climatological patterns. In the continental United States, seasonally high flow normally occurs during the colder period of winter and in early spring from snow melt and spring rain, while seasonally low flow typically occurs during the warmer summer and early fall drought periods. Consistent with our discussion regarding critical conditions, the HSPF model and TMDL analysis will effectively consider seasonal environmental variations.

6) The TMDLs include a margin of safety.

This requirement is intended to add a level of safety to the modeling process to account for any uncertainty. Margins of safety may be implicit, built into the modeling process by using conservative modeling assumptions, or explicit, taken as a percentage of the wasteload allocation, load allocation, or TMDL.

Virginia includes an explicit margin of safety by establishing the TMDL target water quality concentration for fecal coliform at 190 cfu/ 100mL, which is more stringent than Virginia's water quality standard of 200 cfu/100 mL. This would be considered an explicit 5% margin of safety.

7) The TMDLs have been subject to public participation.

This TMDL was subject to a number of public meetings. Three public meetings were held in Glade Spring. The meetings were held on November 09, 1999, January 27, 2000, and March, 2000 and were intended to address initial questions and concerns regarding outreach issues and the TMDL process.

The first public meeting was held on November 9, 1999 in Glade Spring and was announced in the Washington County News on October 27, 1999 and the Virginia Register on November 08, 1999. The second public meeting was announced in the Virginia Register on December 28, 1999, the

Washington County News on January 19, 2000, and the Bristol Herald Courier on January 23, 2000. The March 30, 2000, public meeting was announced in the March 13, 2000 Virginia Register and the local papers. No written comments or responses were provided by VA DEQ with this submission.

8) There is a reasonable assurance that the TMDL can be met.

EPA requires that there be a reasonable assurance that the TMDL can be implemented. WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source.

Nonpoint source controls to achieve LAs can be implemented through a number of existing programs such as Section 319 of the Clean Water Act, commonly referred to as the Nonpoint Source Program. Additionally, Virginia's Unified Watershed Assessment, an element of the Clean Water Action Plan, could provide assistance in implementing this TMDL.

Decision Rationale

Total Maximum Daily Load of
Fecal Coliform for Hutton Creek

I. Introduction

This document will set forth the Environmental Protection Agency's (EPA) rationale for approving the Total Maximum Daily Load (TMDL) of Fecal Coliform for Hutton Creek submitted for final Agency review on January 04, 2001 Our rationale is based on the TMDL submittal document to determine if the TMDL meets the following 8 regulatory conditions pursuant to 40 CFR §130.

1. The TMDLs are designed to implement applicable water quality standards.
2. The TMDLs include a total allowable load as well as individual waste load allocations and load allocations.
3. The TMDLs consider the impacts of background pollutant contributions.
4. The TMDLs consider critical environmental conditions.
5. The TMDLs consider seasonal environmental variations.
6. The TMDLs include a margin of safety.
7. The TMDLs have been subject to public participation.
8. There is reasonable assurance that the TMDLs can be met.

II. Background

Located in Washington County, Virginia, the overall Hutton Creek watershed [1] is approximately 11.2 square miles. The TMDL addresses 4.2 miles of Hutton Creek, from its headwaters to its confluence with the Middle Fork Holston. The Middle Fork Holston flows from southern Virginia to Tennessee.

In response to Section 303 (d) of the Clean Water Act (CWA), the Virginia Department of Environmental Quality (VADEQ) listed 4.2 miles of Hutton Creek as being impaired by elevated levels of fecal coliform on Virginia's 1998 303 (d) list. Hutton Creek was listed for violations of Virginia's fecal coliform bacteria standard for primary contact. The Creek was listed as being benthically impaired as well. Fecal Coliform is a bacterium which can be found within the intestinal tract of all warm blooded animals. Therefore, fecal coliform can be found in the fecal wastes of all warm blooded animals. Fecal coliform in itself is not a pathogenic organism. However, fecal coliform indicates the presence of fecal wastes and the potential for the existence of other pathogenic bacteria. The higher concentrations of fecal coliform indicate the elevated likelihood of increased pathogenic organisms. Hutton Creek identified as watershed VAS-O05R, was given a high priority for TMDL development. Section 303 (d) of the Clean Water Act and its implementing regulations require a

[1] The Hutton watershed is part of Middle Fork Holston hydrologic unit (No. 2070005)

TMDL to be developed for those waterbodies identified as impaired by the State where technology-based and other controls do not provide for the attainment of Water Quality Standards. The TMDL submitted by Virginia is designed to determine the acceptable load of fecal coliform which can be delivered to Hutton Creek, as demonstrated by the Hydrologic Simulation Program Fortran (HSPF)[2], in order to ensure that the water quality standard is attained and maintained. These levels of fecal coliform will ensure that the Primary Contact usage is supported. HSPF is considered an appropriate model to analyze this watershed because of its dynamic ability to simulate both watershed loading and receiving water quality over a wide range of conditions.

The TMDL analysis allocates the application/deposition of fecal coliform to land based and instream sources. For land based sources, the HSPF model accounts for the buildup and washoff of pollutants from these areas. Buildup (accumulation) refers to all of the complex spectrum of dry-weather processes that deposit or remove pollutants between storms.[3] Washoff is the removal of fecal coliform which occurs as a result of runoff associated with storm events. These two processes allow the HSPF model to determine the amount of fecal coliform from land based sources which is reaching the stream. Point sources and wastes deposited directly to the stream were treated as direct deposits. These wastes do not need a transport mechanism to allow them to reach the stream. The allocation plan calls for the reduction in fecal coliform wastes delivered by cattle in-stream and septic systems.

Table #1 summarizes the specific elements of the Hutton TMDL.

Parameter	TMDL(cfu/yr)	WLA(cfu/yr)	LA(cfu/yr)	*MOS* [1] (cfu/yr)
Fecal Coliform	1.35×10^{15}	0	1.28×10^{15}	6.75×10^{13}

1 Virginia includes an implicit MOS by identifying the TMDL target as achieving the total fecal coliform water quality concentration of 190 cfu/100ml as opposed to the WQS of 200 cfu/ml. This can be viewed explicitly as a 5% MOS.

The United States Fish and Wildlife Service has been provided with a copy of this TMDL.

III. Discussion of Regulatory Conditions

EPA finds that Virginia has provided sufficient information to meet all of the 8 basic requirements for establishing a fecal coliform TMDL for Hutton Creek. EPA is therefore approving this TMDL . Our approval is outlined according to the regulatory requirements listed below.

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[2]Bicknell, B.R., J.C. Imhoff, J.L. Little, and R.C. Johanson. 1993. Hydrologic Simulation Program-FORTRAN (HSPF): User's Manual for release 10.0. EPA 600/3-84-066. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.

[3]CH2MHILL, 2000. Fecal Coliform TMDL Development for Cedar, Hall, Byers, and Hutton Creeks Virginia,

1) The TMDL is designed to meet the applicable water quality standards.

Virginia has indicated that excessive levels of fecal coliform due to nonpoint sources (directly deposited into the Creek) have caused violations of the water quality standards and designated uses on Hutton Creek. The water quality criterion for fecal coliform is a geometric mean 200 cfu (colony forming units)/100ml or an instantaneous standard of no more than 1,000 cfu/100ml. Two or more samples over a 30-day period are required for the geometric mean standard. Most of the streams monitored by Virginia are sampled once in a 30-day period. Therefore, most violations of the State's water quality standard are due to violations of the instantaneous standard.

The HSPF model is being used to determine the fecal coliform deposition rates to the land as well as loadings to the stream from point and other direct deposit sources necessary to support the fecal coliform water quality criterion and primary contact use. The following discussion is intended to describe how controls on the loading of fecal coliform to Hutton Creek will ensure that the criterion is attained.

The TMDL modelers determined the fecal coliform production rates within the watershed. Information was attained from a wide array of sources on the farm practices in the area (land application rates of manure), the amount and concentration of farm animals, point sources in the watershed, animal access to the stream, wildlife in the watershed and their fecal production rates, land uses, weather, stream geometry, etc. This information was put into the model. The modelers also assigned values to several parameters that affect the transport of fecal coliform to the stream. The modelers adjusted the parameters to insure a correspondence between observed and simulated conditions

The hydrologic component of the model for all the Middle Fork Holston TMDLs (Cedar, Byers, Hutton, and Hall Creeks) was developed based on Groseclose Creek and then transferred to each individual watershed. This was done because there were no stream gages on the other waters. When the simulated data on Groseclose accurately reflected the observed flow data the model was considered complete and transferred to the other watersheds. The hydrologic parameters were adjusted to match the conditions in each watershed. The model was calibrated to the impaired watersheds by comparing simulated flow results to observed flows (monthly samples).

EPA believes that using HSPF to model and allocate fecal coliform loading, will ensure that the designated uses and water quality standards will be attained and maintained for Hutton Creek.

2) The TMDL includes a total allowable load as well as individual waste load allocations and load allocations.

<u>Total Allowable Loads</u>

Virginia indicates that the total allowable load of fecal coliform is the sum of the loads allocated to land based, precipitation driven nonpoint source areas (impervious areas, built-up area, distributed area, field crop, forest, hayfield, improved pasture, overgrazed pasture, poor pasture, row crop, strip crop), directly deposited nonpoint sources of fecal coliform (cattle in-stream and failed septic systems), and point sources. Activities such as the application of manure, fertilizer, and the direct deposition of wastes from grazing animals are considered fluxes to the land use categories. The actual value for the total fecal load can be found in Table 1 of this document. The total allowable load is calculated on an annual basis due to the nature of HSPF model.

Waste Load Allocations

Virginia has stated that there are no point sources discharging to Hutton Creek. EPA regulations require that an approvable TMDL include individual WLAs for each point source. According to 40 CFR 122.44(d)(1)(vii)(B), "Effluent limits developed to protect a narrative water quality criterion, a numeric water quality criterion, or both, are consistent with assumptions and requirements of any available WLA for the discharge prepared by the State and approved by EPA pursuant to 40 CFR 130.7." Furthermore, EPA has authority to object to the issuance of any NPDES permit that is inconsistent with the WLAs established for that point source.

Load Allocations

According to federal regulations at 40 CFR 130.2 (g), load allocations are best estimates of the loading, which may range form reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading. Wherever possible natural and nonpoint source loads should be distinguished.

In order to accurately simulate landscape processes and nonpoint source loadings, VA DEQ used the HSPF model to represent the Hutton Creek watershed. The HSPF model is a comprehensive modeling system for simulation of watershed hydrology, point and nonpoint loadings, and receiving water quality for conventional pollutants and toxicant[4]. More specifically HSPF uses precipitation data for continuous and storm event simulation to determine total fecal loading to Hutton Creek from impervious areas, built-up area, distributed area, field crop, forest, hayfield, improved pasture, overgrazed pasture, poor pasture, row crop, strip crop. The total land loading of fecal coliform is the result of the application of manure, direct deposition from cattle and wildlife (geese and deer) to the land, fecal coliform production from dogs, and best management practices (which have already been implemented on several farms reduce the loading of fecal coliform and sediment to streams).

In addition, VADEQ recognizes the significant loading of fecal coliform from cattle in-stream and failed septic systems. These two sources are not dependent on a transport mechanism to reach a surface waterbody and therefore can impact water quality during low and high flow events.

[4] Supra, footnote 2.

It should be noted that an extensive amount of BMPs (Best Management Practices) have been implemented within Cedar Creek , Hall/Byers Creek, and Hutton Creek. BMPs have been installed in approximately 17% of the Hutton Creek watershed. Based on the model these BMPs have reduced the fecal coliform loading by 12.2%.

There are three weather stations in the area around the study area. The closest weather station (Helton, NC) had a significantly larger annual rainfall average (53 inches) than the watershed in question. It was decided that the use of this watershed would bias the model toward regulating nonpoint sources (runoff related wastes) and therefore not used. The study area had a mean annual rainfall of 43 inches. Weather stations in Bristol and Wytheville were used because their mean annual rainfall (41 and 39 inches respectively) was closer to the annual rainfall of the study area. The watershed is located halfway between these weather stations. DEQ averaged the rainfall data from these two stations and applied the computed data to the model. This interpretation can affect the model because there maybe some differences between the actual storm event and the computed event. Table 3 illustrates the load allocation for the land application of fecal coliform.

Table 3 - Load allocation for the land application of fecal coliform

Source	Existing Load(cfu/yr)	Allocated Load(cfu/yr)	Percent Reduction
Impervious Areas	4.26E+13	4.26E+13	0%
Built-up Area	1.40E+12	1.40E+12	0%
Forest	1.33E+12	1.33E+12	0%
Hayfield	7.33E+12	6.60E+12	10%
Improved Pasture	9.61E+13	8.65E+13	10%
Overgrazed Pasture	8.29E+14	8.29E+14	0%
Poor Pasture	2.35E+14	2.35E+14	0%
Row Crop	6.45E+13	6.45E+13	0%
Strip Crop	5.12E+12	5.12E+12	0%
Failed Septic Systems	1.03E+12	0.0	100%
Cattle In-Stream	2.59E+13	0.0	100%

3) The TMDL considers the impacts of background pollution.

Fecal coliform loads from deer and geese were considered background loading and were incorporated into the model.

4) The TMDL considers critical environmental conditions.

EPA regulations at 40 CFR 130.7 (c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of Hutton Creek is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards[5]. Critical conditions are a combination of environmental factors (e.g., flow, temperature, etc.), which have an acceptably low frequency of occurrence but when modeled to, insure that water quality standards will be met for the remainder of conditions. In specifying critical conditions in the waterbody, an attempt is made to use a reasonable "worst-case" scenario condition. For example, stream analysis often uses a low-flow (7Q10) design condition because the ability of the waterbody to assimilate pollutants without exhibiting adverse impacts is at a minimum. Virginia's standards are designed to be applied during all flow events.

The sources of bacteria for these stream segments were mixtures of dry and wet weather driven sources. Therefore, the critical condition for Hutton Creek was represented as a typical hydrologic year.

5) The TMDLs consider seasonal environmental variations.

Seasonal variations involve changes in stream flow as a result of hydrologic and climatological patterns. In the continental United States, seasonally high flow normally occurs during the colder period of winter and in early spring from snow melt and spring rain, while seasonally low flow typically occurs during the warmer summer and early fall drought periods. Consistent with our discussion regarding critical conditions, the HSPF model and TMDL analysis will effectively consider seasonal environmental variations.

6) The TMDLs include a margin of safety.

This requirement is intended to add a level of safety to the modeling process to account for any uncertainty. Margins of safety may be implicit, built into the modeling process by using conservative modeling assumptions, or explicit, taken as a percentage of the wasteload allocation, load allocation, or TMDL.

Virginia includes an explicit margin of safety by establishing the TMDL target water quality concentration for fecal coliform at 190 cfu/ 100mL, which is more stringent than Virginia's water quality

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[5]EPA memorandum regarding EPA Actions to Support High Quality TMDLs from Robert H. Wayland III, Director, Office of Wetlands, Oceans, and Watersheds to the Regional Management Division Directors, August 9, 1999.

standard of 200 cfu/100 mL. This would be considered an explicit 5% margin of safety.

7) The TMDLs have been subject to public participation.

This TMDL was subject to a number of public meetings. Three public meetings were held in Glade Spring. The meetings were held on November 09, 1999, January 27, 2000, and March, 2000 and were intended to address initial questions and concerns regarding outreach issues and the TMDL process.

The first public meeting was held on November 9, 1999 in Glade Spring and was announced in the Washington County News on October 27, 1999 and the Virginia Register on November 08, 1999. The second public meeting was announced in the Virginia Register on December 28, 1999, the Washington County News on January 19, 2000, and the Bristol Herald Courier on January 23, 2000. The March 30, 2000, public meeting was announced in the March 13, 2000 Virginia Register and the local papers. No written comments or responses were provided by VA DEQ with this submission.

8) There is a reasonable assurance that the TMDL can be met.

EPA requires that there be a reasonable assurance that the TMDL can be implemented. WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source.

Nonpoint source controls to achieve LAs can be implemented through a number of existing programs such as Section 319 of the Clean Water Act, commonly referred to as the Nonpoint Source Program. Additionally, Virginia's Unified Watershed Assessment, an element of the Clean Water Action Plan, could provide assistance in implementing this TMDL.

Fecal Coliform TMDL Development for Cedar, Hall, Byers, and Hutton Creeks, Virginia

Submitted by

Virginia Department of Environmental Quality
Virginia Department of Conservation and Recreation

Prepared by

CH2MHILL

In association with AQUA TERRA Consultants

OCTOBER, 2000

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Executive Summary

This report presents the development of Total Maximum Daily Loads (TMDLs) for Cedar Creek, Hall Creek, Byers Creek, and Hutton Creek. These creeks are tributaries of the Middle Fork Holston River and were placed on the Commonwealth of Virginia's 303(d) list of water quality impaired water bodies because of violations of the fecal coliform bacteria water quality standard.

Virginia's water quality standard (9 VAC 25-260-170) specifies that in all surface waters, except shellfish waters and certain waters listed in 9 VAC 25-260-170 subsection B of that section of the standard, the fecal coliform bacteria count shall not exceed a geometric mean of 200 per 100 milliliters (mL) of water for two or more samples taken over a 30-day period, or the fecal coliform bacteria count shall not exceed 1,000 per 100 mL at any time.

Water quality data collected in the four watersheds show that bacteria concentrations routinely exceed the water quality standard.

The Cedar Creek, Byers Creek, Hall Creek, and Hutton Creek watersheds are contiguous to each other and are located in Washington County, Virginia. The four creeks flow in a southeasterly direction towards the Middle Fork Holston River (ID VAS-O05R). The watersheds are located within the Middle Fork Holston River hydrologic unit (8-digit HUC: 06010102). Byers Creek confluences with Hall Creek approximately 1.2 miles upstream of the confluence with the Middle Fork Holston River.

The Cedar Creek watershed has approximately 7.3 square miles, the Byers / Hall Creeks watershed has approximately 15.7 square miles, and the Hutton Creek watershed has approximately 11.2 square miles. The primary land use in the watersheds is pasture. Other land uses include crops, forest, and urban areas. Interstate 81 and Route 11 run through the watersheds in a northeast-southeast direction.

A large number of agricultural best management practices (BMPs) have been implemented in these watersheds since the mid 1980's as a result of nonpoint source programs. These programs were led by the Middle Fork Holston River Water Quality Committee and the Tennessee Valley Authority (TVA), in cooperation with the Department of Conservation and Recreation (DCR), and implemented by the property owners in the watersheds with assistance from the Holston River Soil and Water Conservation District, the New River Highlands Resource Conservation and Development Area, and the Natural Resources Conservation Service (NRCS). Agricultural BMPs "cover" approximately 1,157 acres (25%) of the Cedar Creek watershed; 2,036 acres (20%) of the Byers / Hall Creek watershed; and 1,249 acres (17%) of the Hutton Creek.

The U.S. Environmental Protection Agency's (EPA's) HSPF watershed model and Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) analysis system were used to characterize the watersheds and evaluate TMDL allocations. Spatial data (land use and cover, hydrographic and topographic data, and BMP information), monitoring data (water quality, flow, and weather information), and pollutant source data were used to develop input parameters for the watershed models.

The watershed models were calibrated using information from a gage located in the upper reaches of the Middle Fork Holston River at Groseclose [U.S. Geological Survey (USGS) station ID 03473500]. The watershed above this gage is hydrologically similar to Hutton Creek, Hall / Byers Creek, and Cedar Creek watersheds. There are three USGS peak flow gages (crest gages) located in Cedar Creek (station ID 03475600), Hall Creek (station ID 03474800), and Hutton Creek (station ID 03474700) and three Department of Environmental Quality (DEQ) monitoring stations located in each creek. The information from these gages / stations was used to validate the model results.

Bacterial loads were estimated from available information and attributed to the following source categories:

- Nonpoint Sources:
  - Septic systems
  - Wildlife contributions in forested areas and other land uses
  - Land application of manure in field crops, pasture, and hayfields
  - Cattle contributions directly deposited in the stream (cattle in the stream)
  - Grazing animals
  - Impervious areas
  - Urban stormwater runoff from built-up areas
- Point Sources:
  - Meadowview Elementary School located in the Cedar Creek watershed
  - Dillow's Shop and Wash located in the Cedar Creek watershed
  - Emory-Meadowview Wastewater Treatment Plant located in the Hall Creek watershed; Patrick Henry High School located in the Hall Creek watershed; the discharge form this point source was closed in August 1996
  - Emory & Henry College located in the Hall Creek watershed; the discharge from this point source was closed in August 1996

Land application of manure, cows in the stream, grazing animals, and failed septic systems were the sources of greatest significance on an annual basis. Seasonal variations in hydrology, climatic conditions, precipitation, and watershed activities (variation in fecal coliform loads through hourly variation of meteorological data, monthly variation of fecal coliform accumulation rates, and monthly varying fecal coliform loads from cows in the streams) were analyzed in the watershed models by conducting a continuous simulation during a typical hydrologic year. A typical hydrologic year was determined by analyzing precipitation patterns from area rainfall gages.

TMDLs are the sum of the individual waste load allocations (WLAs) for point sources, load allocations (LAs) for both nonpoint sources and natural background, and a margin of safety (MOS). This definition is denoted by the following equation:

$$\text{TMDL} = \Sigma \text{ WLAs} + \Sigma \text{ LAs} + \text{MOS}$$

The fecal coliform TMDL was developed to achieve full compliance with the Virginia's water quality standard for fecal coliform, described above. Specifically, the 200 fecal coliform bacteria counts per 100 mL, geometric mean standard, were used for the TMDL allocations. Table ES-1 summarizes the elements of the TMDL.

TABLE ES-1
Summary of Fecal Coliform TMDL Calculated to Average Annual Loading (counts/year)
Middle Fork Holston River TMDLs

Watershed	TMDL200 [(a)] (counts/year)	WLA [(b)] (counts/year)	LA [(c)] (counts/year)	MOS [(d)] (counts/year)
Cedar Creek	6.07E+14	1.55E+10	5.77E+14	3.04E+13
Hall/Byers Creeks	1.03E+15	7.85E+10	9.83E+14	5.17E+13
Hutton Creek	1.35E+15	0	1.28E+15	6.75E+13

a TMDL200 represents loading that corresponds compliance with the 200 count/100 mL geometric mean standard.
b Derived from Table 5-1, Waste Load Allocation for Point Sources.
c Summation of load allocations from Table 5-2, Cedar Creek; Table 5-3, Hall/Byers Creeks; Table 5-4, Hutton Creek; Existing and Allocated Fecal Coliform Loads.
d A 5% MOS is used to target load reductions to meet a monthly geometric mean of 190 counts/100 mL (i.e., 5% of the 200 counts/100 mL geometric mean standard). In order to express this MOS explicitly for the purpose of this summary, the loading in this table is calculated based on the equation: TMDL200 = WLA + LA + (0.05 TMDL200).
This equation is used for illustration purposes only since the standard is based on concentrations.

Reductions in discharges form failing septic systems and cattle contributions directly deposited in the stream (cows in the stream) will be required in order to achieve compliance with water quality standards in the four creeks.

An initial public meeting was held on November 9, 1999, to present the TMDL process and to discuss the overall approach to the development of TMDLs for the watersheds and preliminary data that had been collected for the watersheds. A second public meeting was held on January 27, 2000, to review the TMDL process and to discuss the watershed characterization and preliminary analysis efforts. A third public meeting was held on March 30, 2000, to present the draft TMDL. Copies of the draft TMDL were available for distribution. A public meeting notice was published in the *Virginia Register* on March 13, 2000. The public comment period ended on April 11, 2000.

1.0 Introduction

1.1 Background

Section 303(d) of the Federal Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to identify water bodies not meeting state water quality standards and to develop Total Maximum Daily Loads (TMDLs) for these water bodies. The TMDL process establishes that allowable loading of pollutants or other quantifiable parameters for a water body be based on the relationship between pollution sources and instream conditions. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991).

High levels of fecal coliform bacteria have been recorded throughout four watersheds – Cedar Creek, Hall Creek, Byers Creeks, and Hutton Creek. These creeks are tributaries of the Middle Fork Holston River and were placed on the Commonwealth of Virginia's 303(d) list of water quality impaired water bodies for fecal coliform bacteria. Fecal coliform bacteria are used as indicators for pathogenic microorganisms which can cause gastrointestinal illness through ingestion or by entering through broken skin.

This report presents the development of TMDLs for Cedar Creek, Hall Creek, Byers Creek, and Hutton Creek. The watersheds of these four creeks are contiguous to each other and are located in Washington County, Virginia. Figure 1-1 shows the location of these watersheds and the location of gaging stations and monitoring stations used in the analysis. Figure 1-1 also shows the location of a watershed in the upper reaches of the Middle Fork Holston River watershed that was used for calibrating the watershed models.

The Commonwealth of Virginia through the Department of Conservation and Recreation (DCR) and the Department of Environmental Quality (DEQ) must submit to EPA the TMDL final reports for the four impaired stream segments within the Middle Fork Holston River watershed no later than May 2000 and must conduct internal reviews and a 30-day public comment period prior to this submission.

1.2 Applicable Water Quality Standards

All waters of Virginia, including Cedar Creek, Hall Creek, Byers Creek, and Hutton Creek are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish) (9VAC25-260-10). The four creeks were listed on the Virginia DEQ 1998 303(d) list for violations of the state fecal coliform bacteria standard applied for contact recreational uses (e.g., swimming and boating).

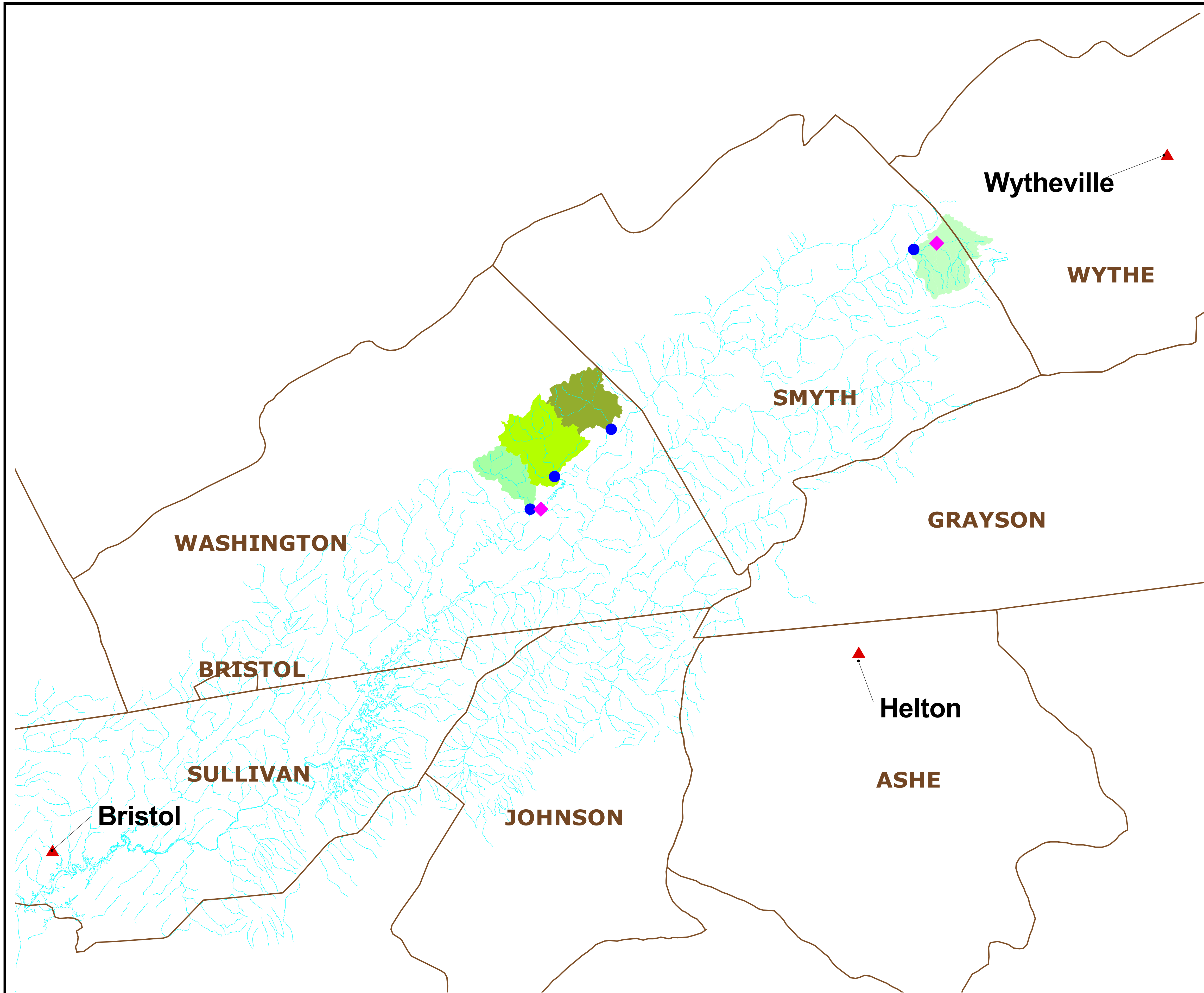


Figure 1-1
Location of Watersheds and Data Collection Stations
Middle Fork Holston River TMDL
(Cedar, Hall, Byers, and Hutton Creeks)

Sufficient fecal coliform bacteria standard violations were identified during a study published by the Mount Rogers Planning District Commission in 1991 and a special study conducted in 1997 by DEQ. These data were used by DEQ to indicate that the recreational use designations are not being supported (DEQ 1998) in the four creeks.

Virginia's water quality standard for fecal coliform bacteria in the four creeks can be applied in the following two ways (9 VAC 25-260-170):

- The fecal coliform bacteria count shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 milliliters (mL) of water for two or more samples taken over a 30-day period.
- The fecal coliform bacteria count shall not exceed the level of 1,000 per 100 mL at any time.

Most of DEQ's ambient water quality monitoring is done on a monthly or bimonthly basis. This sampling frequency does not provide the two or more samples within 30 days needed for use of the geometric mean part of the standard. Therefore, DEQ uses the 1,000 per 100 mL part of the standard in the assessment of the fecal coliform bacteria monitoring data.

Prior to 1992, Virginia's fecal coliform standard only had one criterion, the geometric mean of 200 fecal coliform bacteria per 100 mL for two or more samples within a 30-day period. DEQ's monthly monitoring program was and remains designed to collect one sample per month. The problem was that monthly monitoring did not produce sufficient data to allow an assessment of compliance with Virginia's fecal coliform standard.

To correct this situation, the fecal coliform standard was modified by adding an additional criterion: the 1,000 per 100 mL maximum if only one sample is available during a 30-day period. This criterion was added to the standard specifically to allow compliance to be assessed based on the data from our monthly monitoring program.

DEQ's intent and implementation of this standard has been and continues to be that one or the other criteria, but not both, apply to a particular set of data or datum. For example:

- One sample result within a 30-day period that is equal to or less than 1,000 fecal coliform bacteria per 100 mL of water does not violate the standard.
- Two or more sample results within a 30-day period that yield a geometric mean equal to or less than 200 fecal coliform bacteria per 100 mL of water does not violate the standard regardless of the maximum value of the sample results.
- When assessing a set of monthly monitoring data, DEQ equates one sample per month to one sample within 30 days even if there are instances where the actual periods between two samples are 30 days or less.

DEQ applies the geometric mean criteria of 200 fecal coliform bacteria to monitoring data sets generated from special monitoring programs or projects designed to produce multiple samples over periods shorter than a month.

TMDL calculations and modeling predictions which are based on and are to be verified by DEQ's monthly water quality monitoring program should always use the criteria for one sample per 30 days. Model simulations can generate multiple data points within a 30-day period for application of the geometric mean criteria. However, the 1,000 per 100 mL criteria should always be used where monthly monitoring data are to be used in evaluations and analysis of compliance with the fecal coliform bacteria standard (Muddy Creek Workgroup, 1999).

2.0 Water Quality Targets (TMDL Endpoint)

2.1 Selection of the Water Quality Targets (TMDL Endpoint)

Cedar Creek, Hall Creek, Byers Creek, and Hutton Creek were placed on the Virginia 1998 303(d) list due to violations of the state fecal coliform bacteria standard applied for contact recreational uses (e.g., swimming and boating). These violations of the standard were based on a special study conducted by DEQ in 1997 and on a study conducted by the Mount Rogers Planning District Commission between 1987 and 1989 and published in 1991. The following are the impaired segments in the four watersheds according to the fact sheets provided in the 1998 303 (d) list:

- The Cedar Creek TMDL addresses 5.24 miles of stream from the headwaters to the confluence with the Middle Fork Holston River.
- The Hall Creek TMDL addresses 5.87 miles of stream from the headwaters to the confluence with Byers Creek.
- The Byers Creek TMDL addresses 1.19 miles of stream from the confluence with Hall Creek to the confluence with the Middle Fork Holston River.
- The Hutton Creek TMDL addresses 4.2 miles of stream from the headwaters to the confluence with the Middle Fork Holston River.

One of the major components of a TMDL is the establishment of instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints; therefore, represent the *water quality targets* that are to be achieved by implementing the load reductions specified in the TMDL. The endpoints allow for a comparison between observed instream conditions and conditions that are expected to restore designated uses. The endpoints are usually based on either the narrative or numeric criteria available in state water quality standards (Muddy Creek Workgroup, 1999).

For the TMDLs in this report, the applicable endpoints and associated target values can be determined directly from the Virginia water quality standards. The instream fecal coliform target for the four creeks' TMDLs is a maximum geometric mean of 200 counts per 100 mL in any representative set of samples with 0 percent violations.

The instream fecal coliform target was selected because the data and modeling are better suited to describe mean conditions rather than extreme counts.

2.2 Selection of a Critical Condition

Concurrent with the selection of a numeric concentration target, the TMDL development must also define the environmental conditions that will be used when defining allowable loads. Many TMDLs are designed around the concept of a "critical condition." The critical condition is defined as the set of environmental conditions, which, if controls are designed to protect, will ensure attainment of objectives for all other conditions. For example, the critical condition for control of a continuous point discharge is the drought stream flow when dilution is at a minimum. Pollution controls designed to meet water quality standards for drought flow conditions will ensure compliance with standards for all other conditions. The critical condition for a wet weather-driven source, such as urban and agricultural runoff, may be a particular rainfall event.

Bacteria sources to the four watersheds arise from a mixture of continuous or dry weather and wet weather-driven sources, and there may be no single critical condition that is protective for all other conditions. For example, leaking septic system loading is assumed to be relatively constant over time, and its control will be most critical during drought conditions. Urban and agricultural runoff, on the other hand, will be most critical during wet weather periods. For this reason and because fecal coliform violations within the four watersheds are attributed to both nonpoint and direct instream sources, the *critical condition* used for the analysis and evaluation of the watershed responses was represented by a typical hydrologic year, with dry and wet periods, that was determined based on long term rainfall records.

As we find in the final allocation scenarios (Section 5.2.2), there is no need for reduction in fecal coliform load for land applied waste to meet the water quality standard in Cedar and Hall/Byers Creek watersheds. In the Hutton Creek watershed, 10 percent reduction in land applied waste on improved pasture and hayfield is needed to meet the water quality standard. Many agricultural best management practices (BMPs) were already implemented in the Cedar Creek, Hall/Byers Creek, and Hutton Creek watersheds and a 12-15.6 percent reduction in fecal coliform loads were already obtained as shown by the model. The model showed that further reduction in fecal coliform load to meet the water quality standard can be best achieved by reducing the load from direct deposition to the streams. Development of allocation scenarios addressing both dry and wet weather conditions were possible through the selection of an appropriate hydrologic period that was not too wet or too dry.

3.0 Watershed Characterization and Source Assessment

This section describes the data acquired and the resulting watershed characterization conducted in support of the development of TMDLs for the following four watersheds:

- Cedar Creek
- Hall Creek
- Byers Creek
- Hutton Creek

Watershed characterization includes the determination of data sets best suited for the TMDL development, the understanding of the state of the watershed and its elements, and the assessment of all potential sources of fecal coliform bacteria. The quality of the data acquired was assessed, including the identification of gaps in the data record, allowing for the correction of any erroneous or missing data before advancing to the modeling task.

Analysis of limited water quality and flow data available for Cedar Creek, Hall Creek, Byers Creek, and Hutton Creek watersheds showed that although the fecal coliform concentrations increase during storm events, frequent exceedences of 200 counts per 100 mL under low flow condition may contribute significantly to the violation of the water quality standard. Therefore, understanding the direct contribution of fecal coliform load to the streams and the surface runoff process in the watershed will facilitate characterization of the water quality problems in these watersheds.

Table 3-1 lists different Geographic Information System (GIS) data sets collected for setting up the watershed models for TMDL development. Each individual data set is further described in subsequent sections of this document.

3.1 Watershed Description and Setting

Cedar Creek, Byers Creek, Hall Creek, and Hutton Creek are tributaries of the Middle Fork Holston River. The watersheds are contiguous to each other and are located in Washington County, Virginia. Byers Creek confluences with Hall Creek approximately 1 mile upstream of the confluence with the Middle Fork Holston River.

The four creeks flow in a southeasterly direction towards the Middle Fork Holston River (ID VAS-O05R). The watersheds are located within the Middle Fork Holston River hydrologic unit (8-digit HUC: 06010102).

The Cedar Creek watershed has approximately 7.3 square miles, the Byers / Hall Creeks watershed has approximately 15.7 square miles, and the Hutton Creek watershed has approximately 11.2 square miles. The primary land use in the watersheds is pasture. Other land uses include crops, forest, and urban areas. Interstate 81 and Route 11 run through the watersheds in a northeast-southeast direction.

TABLE 3-1
Available GIS Data for Cedar, Hall, Byers, and Hutton Creek Watersheds
Middle Fork Holston River TMDLs

Data Layer	Digital File Type	Source	Date
Land Use	ArcInfo export files	DCR[1]	1985
Stream	Reach File, V3	EPA	1999
Weather Data	ASCII	EPA/NOAA	1999
Topography	Digital Elevation Model	USGS	1999
Watershed Boundaries	ArcInfo export files	TVA	1985
BMP	ArcInfo point files	DCR	1999
Point Sources	ArcInfo point	DEQ	1999
Livestock access to streams	ArcInfo point	NRCS	1985-1989
Livestock type and estimated number	ArcInfo point	NRCS[2]	1999
Sewer Network	CAD	Washington County Service Authority	1999

[1] Information based on data provided by the Tennessee Valley Authority (TVA)
[2] Information received in hard copy form during a meeting with the Natural Resources Conservation Service (NRCS) and the New River Highlands Resource Conservation and Development (RC&D) personnel (Copenhaver, 1999b and Boring, 1999).

A paired watershed approach was selected to calibrate the watershed models. The section of the watershed that will be used as a control watershed is located upstream of U.S. Geological Survey (USGS) Gage (03473500) at Groseclose in the upper reaches of the Middle Fork Holston River. Therefore, the discussion on different data sets used for TMDL development will also include a discussion of the data for the Middle Fork Holston River watershed at Groseclose.

3.2 Watershed Identification and Delineation

3.2.1 Watershed Boundaries

DCR provided watershed boundaries based on the state's 14-digit Hydrologic Unit Code (HUC). These watersheds are smaller than the standard 8-digit HUC boundaries used by the USGS. Hutton and Cedar Creeks have their own watershed boundary while Hall and Byers Creeks share an inclusive watershed boundary. The watersheds were further segmented to delineate the subwatershed boundaries for each reach of Cedar, Hall, Byers, and Hutton Creeks. The subwatershed boundaries were drawn on USGS 7.5-minute topographic quadrangle maps and digitized to develop GIS coverage.

Figure 3-1 shows the delineated subwatershed boundaries. Subwatersheds for the Middle Fork Holston River at Groseclose were also delineated using the procedures described above. Figure 3-2 shows the delineated subwatershed boundaries for Groseclose.

3.2.2 Watershed Topography

Topographic data are used to set up the model and to analyze the model results. Elevations and slopes of land and streams are input directly to the model. Subwatershed boundaries are delineated based on the topographic data and provide a starting point for all analysis.

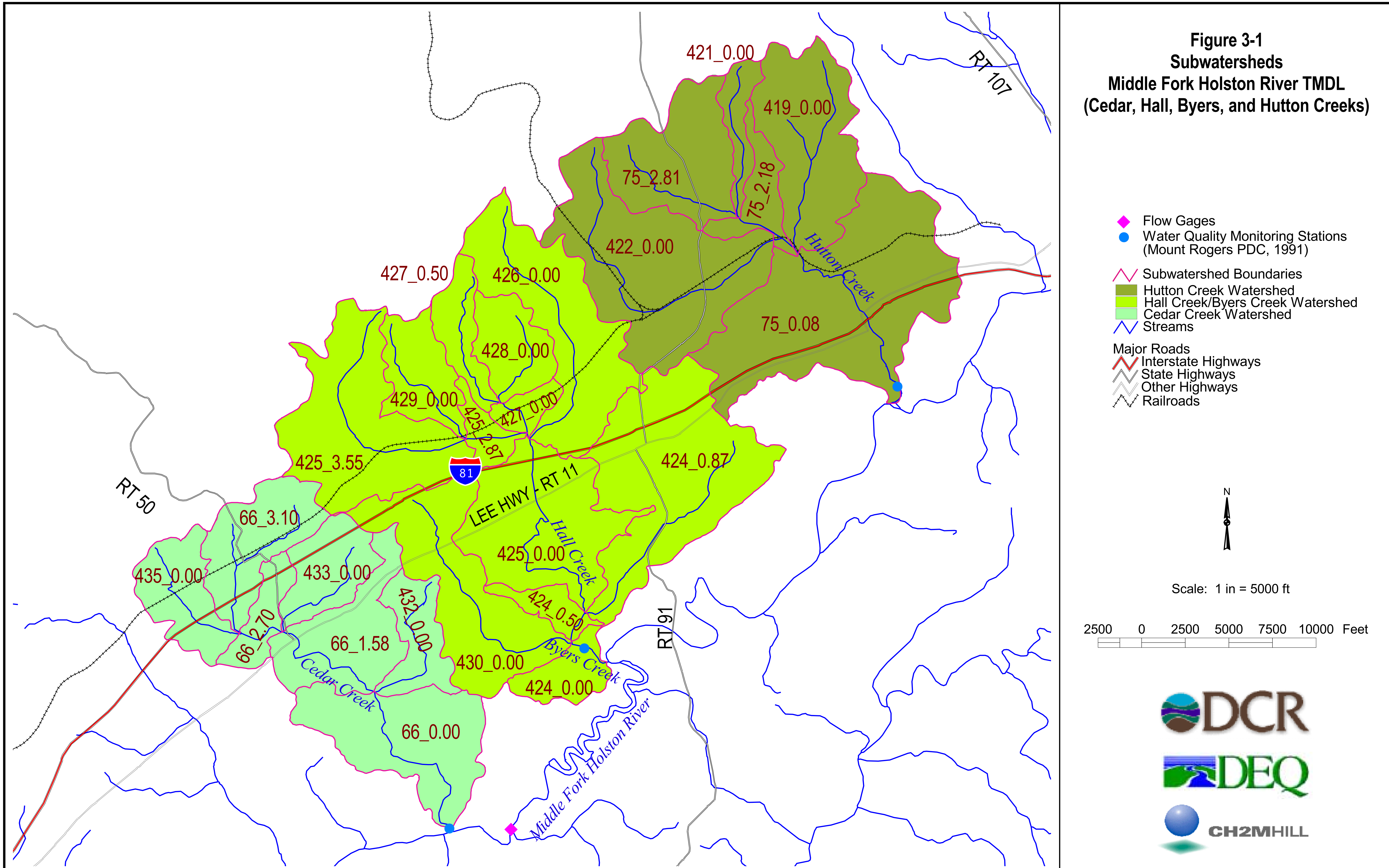
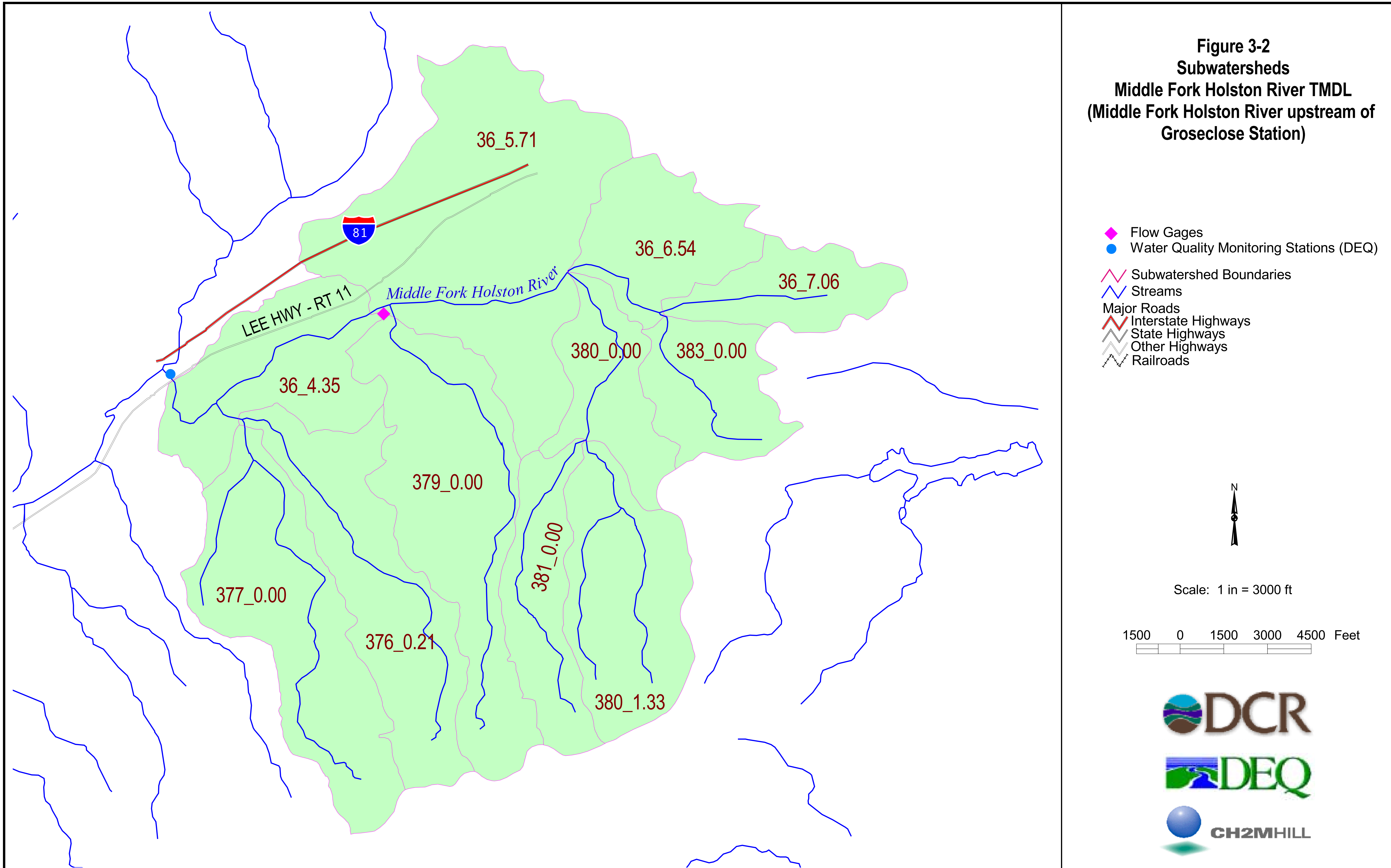


Figure 3-1
Subwatersheds
Middle Fork Holston River TMDL
(Cedar, Hall, Byers, and Hutton Creeks)

Figure 3-2
Subwatersheds
Middle Fork Holston River TMDL
(Middle Fork Holston River upstream of Groseclose Station)



BASINS includes a processed Digital Elevation Model (DEM) data set which is too coarse for any practical use. Upon reviewing the DEM data available from USGS, CH2M HILL used hardcopies of USGS 7.5-minute topographic quadrangles as a base map for delineating subwatershed boundaries and deriving topographic information.

The following USGS quadrangle maps cover the four watersheds being studied: Hayters Gap, Glade Spring, Damascus, and Chilhowie Quadrangles. The Middle Fork Holston River watershed at Groseclose is covered by the Rural Retreat and Cedar Springs Quadrangles.

3.3 Watershed Physical Characteristics

3.3.1 Land Use

Land use data was provided by DCR for the entire Middle Fork Holston watershed (8-digit HUC, 06010102). CH2M HILL used the watershed boundaries described in section 3.2.1 to determine the distribution of different land uses in each watershed. Table 3-2 is a summary of each land use type found in the land use coverage. The land use classification was developed by TVA and used by DCR.

TABLE 3-2
Land Use Descriptions in Cedar, Hall, Byers, and Hutton Creek Watersheds
Middle Fork Holston River TMDLs

Land Use Type	Description
Disturbed Area	Little or no cover, strip mines, construction sites
Field Crop	Winter cover crop such as wheat, barley, rye
Forest	Open Space – Forest
Improved Pasture	Pasture that has been restored. Corresponds to TR-55 Good Pasture (>75% cover)
Improved Pasture, Hayfield	Pasture that has been restored. Corresponds to TR-55 Good Pasture (>75% cover). Hay is periodically cut.
Low Brush (10 ft)	Open Space – Shrub/Scrub
Overgrazed Pasture	Corresponds to TR-55 Fair Pasture (50-75% cover)
Overgrazed Pasture, Gullied	Over grazed pasture with eroded channels, too large to be obliterated by normal tillage operations.
Poor Pasture, Gullied	Poor pasture with eroded channels, too large to be obliterated by normal tillage operations.
Poor Pasture, Little Cover	Corresponds to TR-55 Poor Pasture (<50% cover)
Reclaimed Forest	Open Space – Forest (previously cleared)
Residential Trailer Park	Multiple Mobile Homes on same parcel
Row Crop	Crops planted in rows to allow cultivation between rows.
Row Crop Strip	Growing different row crops in alternating strips or bands along contours.
Row Crop, Gullied	Row crop fields with eroded channels, too large to be obliterated by normal tillage operations.
Unimproved Pasture	
Urban Land: Built-up area	Residential/Commercial areas.
Water	

Figure 3-3 shows the distribution of land uses (historic - 1985) in the watersheds based on the data obtained from DCR. These data were based on 1985 aerial photography provided by TVA. Two small areas within the Hall Creek and Cedar Creek watersheds did not have identified land uses in the DCR coverage. Land use information for the two areas was obtained from NRCS and New River Highlands RC&D staff (Copenhaver, 1999b).

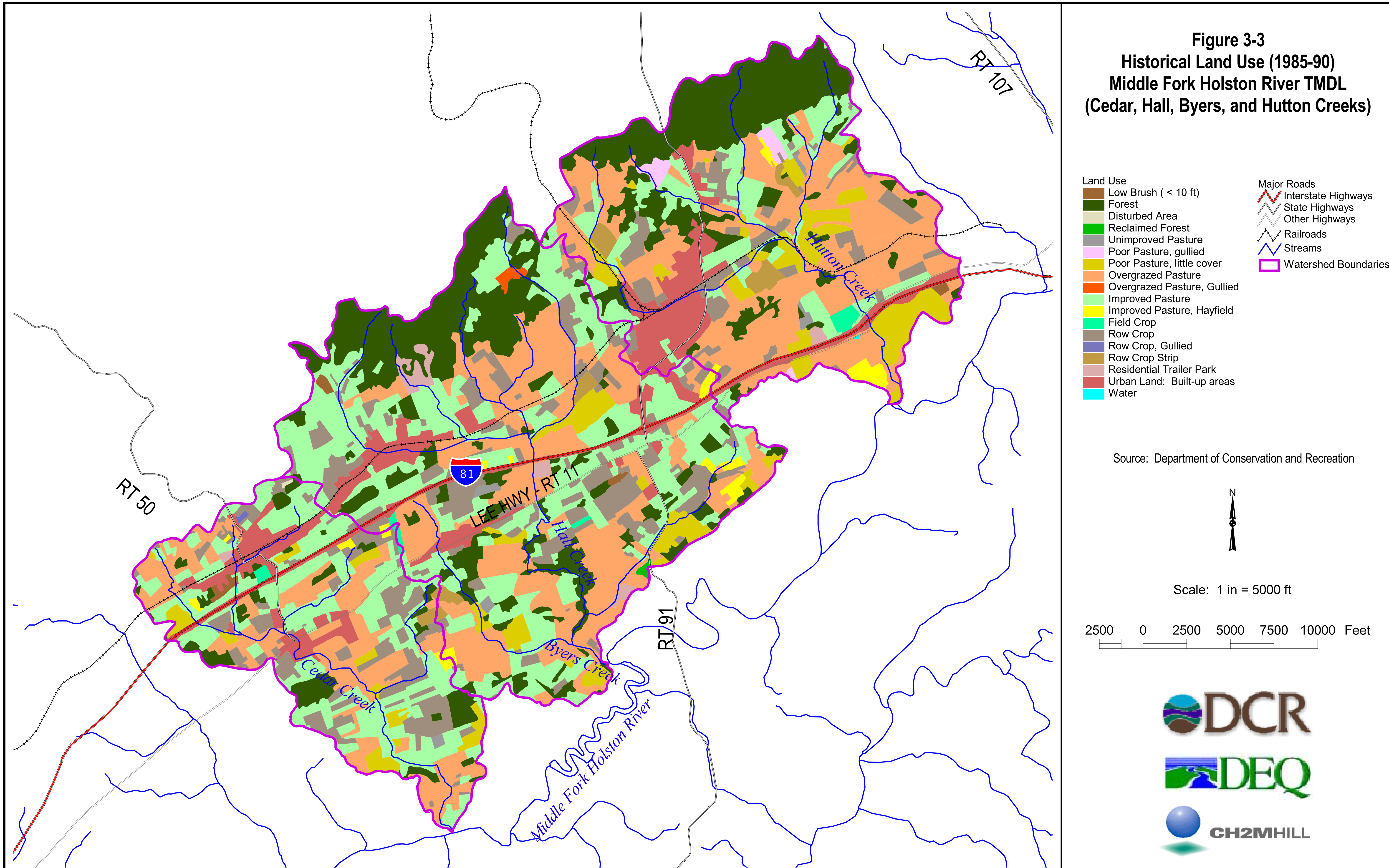
Table 3-3 presents a summary of land use information for each of the watersheds based on data obtained from DCR. This information represents the historical (1985) land uses.

TABLE 3-3
Historical Land Use by Watershed (1985)
Middle Fork Holston River TMDLs

Land Use	Cedar Creek Area (ac)	Hall/Byers Creek Area (ac)	Hutton Creek Area (ac)	Total Area (ac)
Disturbed Area	3.2	0.0	0.0	3.2
Field Crop	20.0	21.2	37.7	79.0
Forest	353.8	2,044.9	1,615.7	4014.4
Improved Pasture	1,602.4	2,892.5	900.6	5,395.6
Improved Pasture, Hayfield	35.8	94.4	74.0	204.2
Low Brush (10 ft)	22.5	24.5	10.0	57.0
Overgrazed Pasture	1,106.2	2,550.4	2,337.5	5,994.1
Overgrazed Pasture, Gullied	0.0	0.0	0.0	0.0
Poor Pasture, Gullied	0.0	0.0	83.4	83.4
Poor Pasture, little cover	223.1	389.5	633.1	1,245.6
Reclaimed Forest	0.0	10.9	0.0	10.9
Residential Trailer Park	8.4	112.4	17.1	137.9
Row Crop	736.6	1,156.1	563.7	2,456.5
Row Crop Strip	23.8	59.5	121.9	205.1
Row Crop, Gullied	5.4	0.0	0.0	5.4
Unimproved Pasture	10.2	27.8	22.2	60.2
Urban Land: Built-up area	477.1	606.8	730.5	1,814.4
Water	0.9	0.0	1.2	2.1
Total	4,629	9,991	7,149	21,770

Since 1985 there have been changes in land use that needed to be incorporated to reflect existing conditions. Staff from NRCS and the RC&D provided the information necessary to update the land use information during a December 9, 1999, meeting. Figure 3-4 shows the land uses (existing in 1999) that are used to represent existing conditions in the watershed.

Figure 3-3
Historical Land Use (1985-90)
Middle Fork Holston River TMDL
(Cedar, Hall, Byers, and Hutton Creeks)



DCR
DEQ
CH2MHILL

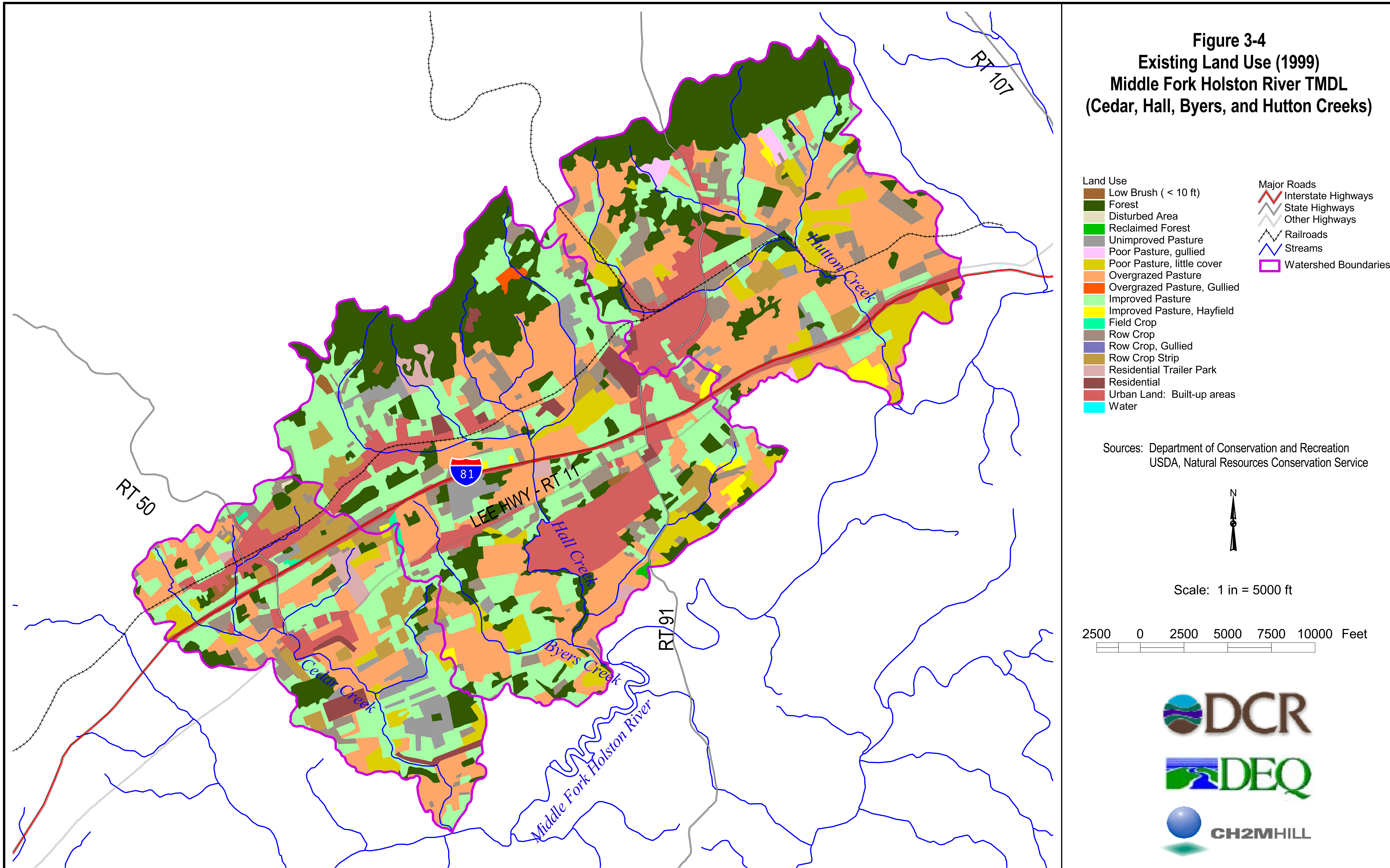


Figure 3-4
Existing Land Use (1999)
Middle Fork Holston River TMDL
(Cedar, Hall, Byers, and Hutton Creeks)
Land Use
Low Brush (< 10 ft)
Forest
Disturbed Area
Reclaimed Forest
Unimproved Pasture
Poor Pasture, gullied
Poor Pasture, little cover
Overgrazed Pasture
Overgrazed Pasture, Gullied
Improved Pasture
Improved Pasture, Hayfield
Field Crop
Row Crop
Row Crop, Gullied
Row Crop Strip
Residential Trailer Park
Residential
Urban Land: Built-up areas
Water
Major Roads
Interstate Highways
State Highways
Other Highways
Railroads
Streams
Watershed Boundaries
Sources: Department of Conservation and Recreation
USDA, Natural Resources Conservation Service
N
Scale: 1 in = 5000 ft
2500 0 2500 5000 7500 10000 Feet
RT 107
RT 50
RT 91
81
LEE HWY - RT 11
Hutton Creek
Hall Creek
Byers Creek
Cedar Creek
Middle Fork Holston River
DCR
DEQ
CH2MHILL

Table 3-4 presents a summary of land use information for each of the watersheds based on the data obtained from DCR. This information represents the existing (1999) land uses.

Land use data will be used in the watershed models to represent the land use conditions when the water quality data was collected in the watersheds.

TABLE 3-4
Existing Land Use by Watershed (1999)
Middle Fork Holston River TMDLs

Land Use	Cedar Creek Area (ac)	Hall/Byers Creek Area (ac)	Hutton Creek Area (ac)	Total Area (ac)
Disturbed Area	3.2	0.0	0.0	3.2
Field Crop	16.5	14.2	0.0	30.7
Forest	354.5	1,961.8	1,636.2	3,952.4
Improved Pasture	1,274.7	2,772.9	9,62.7	5,010.2
Improved Pasture, Hayfield	35.8	94.4	74.0	204.2
Low Brush (10 ft)	22.5	29.6	10.0	62.1
Overgrazed Pasture	1,039.8	2,192.4	2,283.9	5,516.1
Overgrazed Pasture, Gullied	0.0	27.2	0.0	27.2
Poor Pasture, Gullied	200.1	380.8	604.9	1,185.8
Poor Pasture, little cover	0.0	0.0	83.4	83.4
Reclaimed Forest	0.0	10.9	0.0	10.9
Residential Trailer Park	118.1	155.3	15.4	288.9
Row Crop	87.9	112.4	0.0	200.3
Row Crop Strip	266.6	659.2	519.9	1,445.6
Row Crop, Gullied	482.1	219.0	159.7	860.7
Unimproved Pasture	258.4	206.4	67.6	532.5
Urban Land: Built-up area	468.4	1,154.5	730.5	2,353.4
Water	0.9	0.0	1.2	2.1
Total	4,629	9,991	7,149	21,770

3.3.2 Weather Data

Meteorological data was obtained from two sources, EarthInfo and the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC). CH2M HILL investigated the availability of meteorological data at an hourly interval and found three stations in the surrounding areas of the watersheds. These three stations are located at Helton, NC; Wytheville, VA; and Bristol WSO Airport, TN.

Some local stations (e.g., Emory-Henry College) measure precipitation and temperature data but these stations do not have adequate historic data or recorded only daily values. Therefore, the data from three major weather stations were analyzed further to determine appropriate data sets for the TMDL development.

A geographic coverage of annual rainfall was obtained from the PRISM Climate Mapping Program of the Oregon State University to visualize the distribution of rainfall in the region. Figure 3-5 shows the spatial distribution of the mean annual rainfall for the region. This information was used to determine which of the three weather stations nearest to the watersheds are representative of the conditions in the watersheds.

While the Helton, NC, station is closest to the watersheds (22 miles to the center of Hall Creek watershed), Figure 3-5 shows that it has a mean annual rainfall of 51 inches which is much greater than the 43 inches for the study area. The weather station at Bristol Airport has a mean annual rainfall of 41 inches and the Wytheville station has a mean annual rainfall of 39 inches. The Bristol and Wytheville stations appear to have much closer rainfall patterns to the area in question than the Helton station. This is probably due to the fact that the Bristol and Wytheville stations are in the same valley as the study area while the Helton station is located on the other side of Mount Rogers (highest point in the area).

Additional rainfall data was obtained from Emory and Henry College, located in the Hall Creek watershed. The data set is for 1998 and 1999. The rain gage location is approximately in the center of the four watersheds. These data were not used in the watershed models because the dates of the data available did not coincide with the modeling periods.

Rainfall varies both in time and space. In order to setup the watershed model, it is important to know the spatial distribution of precipitation. The simplest and most direct approach for determining spatial distribution of rainfall based on point data (weather station data) is to use the arithmetic average of recorded quantities (Viessman, et al, 1989, Chow, et al, 1988). This procedure, called arithmetic mean method, is satisfactory if weather stations are uniformly distributed and the topography is flat. Since the study area is nearly halfway between the Bristol and Wytheville stations, the first criteria for applicability of the arithmetic mean method is met. The topography of the area is not flat, but the Bristol and Wytheville stations are located in the same valley and in a similar isohyetal region (Figure 3-5). Therefore, the arithmetic mean method can be applied to calculate the precipitation in the four watersheds. Since other stations (e.g., Helton, NC) are located in a very different isohyetal region, the Thiessen method, using more than two stations (Bristol and Wytheville), will not provide any better spatial distribution of rainfall.

Further comparison of weather data at Bristol and Wytheville suggests that the timing, frequency, and magnitude of precipitation at these locations are similar and provides a better representation of the rainfall patterns in the study watersheds. Therefore, a synthetic weather data set was generated using the arithmetic mean method to better represent the conditions at the study area by calculating the average condition of the two stations. Because of the proximity to the Wytheville station, weather data from the Wytheville station was used for model calibration of the Groseclose watershed.

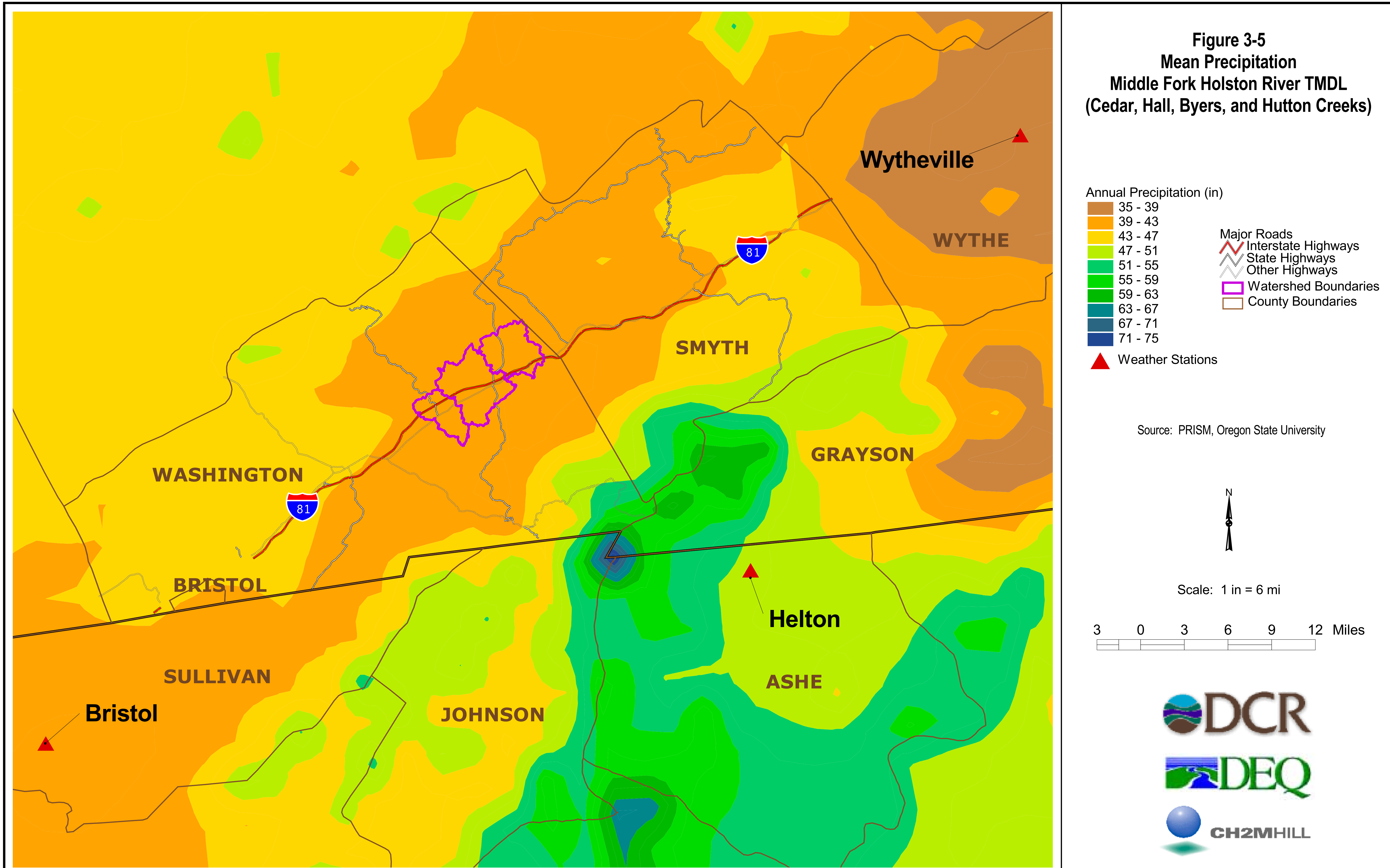


Figure 3-5
Mean Precipitation
Middle Fork Holston River TMDL
(Cedar, Hall, Byers, and Hutton Creeks)
Annual Precipitation (in)
35 - 39
39 - 43
43 - 47
47 - 51
51 - 55
55 - 59
59 - 63
63 - 67
67 - 71
71 - 75
Weather Stations
Major Roads
Interstate Highways
State Highways
Other Highways
Watershed Boundaries
County Boundaries
Source: PRISM, Oregon State University
N
Scale: 1 in = 6 mi
3 0 3 6 9 12 Miles
Wytheville
WYTHE
SMYTH
GRAYSON
WASHINGTON
BRISTOL
SULLIVAN
Bristol
JOHNSON
ASHE
Helton
81
81

3.3.3 Hydrographic Data

Hydrographic data (stream networks and reaches) was obtained from DCR. This data was compared to the Reach File V3 (RF3) data from Basins 2.0. Both data sets had identical basic reach information. The RF3 data will be used in the course of the development of the TMDLs, since it includes more attribute information, and, thus, it is easier to use in Basins.

A summary of the RF3 reaches in the three watersheds, including segment length can be found in Table 3-5. Names of some reaches were added in the RF3 database according to the information obtained from USGS 7.5-minute topographic quadrangles. Other parameters, such as depth and width data, were collected for five of the reaches during a site reconnaissance. The development of the depth and width data, as well as flow rating tables, is discussed in Section 4, Modeling Approach and Assumptions.

TABLE 3-5
RF3 Reach Information Summary
Middle Fork Holston River TMDLs

Reach Number	Reach Name	Length (miles)
6010102 66 0.00	Cedar Creek	2.19
6010102 66 1.58	Cedar Creek	1.54
6010102 66 2.70	East Fork Cedar Creek	0.55
6010102 66 3.10	West Fork Cedar Creek	0.80
6010102 66 3.68	Cedar Creek	0.49
6010102 432 0.00	Cedar Creek	1.82
6010102 433 0.00	East Fork Cedar Creek	1.42
6010102 434 0.00	Cedar Creek	1.08
6010102 435 0.00	West Fork Cedar Creek	1.55
6010102 424 0.00	Byers Creek	0.50
6010102 424 0.50	Hall Creek	0.37
6010102 424 0.87	Tattle Branch	2.73
6010102 425 0.00	Hall Creek	2.79
6010102 425 2.79	East Fork Hall Creek	0.07
6010102 425 2.87	Richardson Branch	0.68
6010102 425 3.55	Hall Creek	2.88
6010102 426 0.00	East Fork Hall Creek	3.13
6010102 427 0.00	Richardson Branch	0.50
6010102 427 0.50	Richardson Branch	1.69
6010102 428 0.00	Richardson Branch	1.17
6010102 429 0.00	Hall Creek	1.70
6010102 430 0.00	Indian Run	2.88
6010102 75 0.08	Hutton Creek	2.47
6010102 75 2.18	Plum Creek	0.17
6010102 75 2.33	Hutton Creek	0.56
6010102 75 2.81	Hutton Creek	1.59
6010102 419 0.00	Plum Creek	0.98

TABLE 3-5
RF3 Reach Information Summary
Middle Fork Holston River TMDLs

Reach Number	Reach Name	Length (miles)
6010102 419 0.98	Plum Creek	1.18
6010102 420 0.00	Plum Creek	0.53
6010102 421 0.00	Hutton Creek	1.72
6010102 422 0.00	Hutton Creek	4.02

3.3.4 Flow Data

The Mount Rogers Planning District Commission, with assistance from the USGS, conducted instantaneous flow measurements at three locations during the 1987-1989 period (Report of Water Quality Monitoring on the Middle Fork Holston River in Smyth and Washington Counties, 1991). These data are listed in Table 3-6.

TABLE 3-6
Flow Measurements from the Mount Rogers PDC Report
Middle Fork Holston River TMDLs

	Cedar Creek Near Cedarville, VA (03475602, lat 36 42 53N, long 081 49 51W)		Byers Creek Near Glade Spring, VA (03474900, lat 36 44 22N, long 081 47 57W)		Hutton Creek Near Chilhowie, VA (03474720, lat 36 46 21N, long 081 43 49W)	
Date	Time	Flow (cfs)	Time	Flow (cfs)	Time	Flow (cfs)
Dec 14, 1987	1000	2.0	0915	4.3	1200	2.9
Feb 03, 1988	1140	5.8	1315	14.0	0945	11.0
Apr 19, 1988	1145	4.9	1315	12.0	0950	8.71
Jun 27, 1988	1045	1.6	1240	5.0	0900	3.1
Aug 17, 1988	1040	1.3	1215	3.8	0900	2.4
May 02, 1989	-	9.12	-	25.3	-	26.0
May 06, 1989	-	-	-	29.5	-	29.7
Jun 17, 1989	-	13.2	-	-	-	41.8
Jul 06, 1989	-	10.6	-	-	-	33.2

Due to lack of continuous flow monitoring stations in the four watersheds, a paired watershed approach was selected for hydrologic calibration of the model. The selected paired watershed is located in the upper reaches of the Middle Fork Holston River.

The daily flow data for the paired watershed were obtained for the period 1987-1989 at the USGS gage (03473500) located at the Middle Fork Holston River at Groseclose. The watershed model was setup for the watershed upstream of the gage and the daily flow data was used for initial calibration of the model. A further verification of the model was performed at the Cedar Creek, Hall Creek, and Hutton Creek watersheds using flow data collected from different sources and frequencies.

In addition, there are three USGS gages 03474700, 03474800, and 03475600 in the study area that measured annual peak flows. Table 3-7 shows a comparison of the data available from these gages to the data available from the paired watershed.

TABLE 3-7
Comparison of Hydrologic Data in the Project Watersheds
Middle Fork Holston River TMDLs

Station Number	Station Name	Peak Discharge Region	Drainage Area (sq. miles)	Daily Flow Data	Mean Annual Precip. (inch)	24-Hour, 2-Year Rainfall (inch)`
03473500	MF Holston River at Groseclose	Southern Valley and Ridge (SV)	7.39	Yes	39.0	2.69
03474700	Hutton Creek near Chilhowie	SV	8.32	No	43.0	2.50
03474800	Hall Creek near Glade Spring	SV	7.9	No	43.5	2.55
03475600	Cedar Creek near Meadowview	SV	3.38	No	44.4	2.72

Table 3-8 presents flows for different return periods. These flows were calculated by developing regression equations between the stations listed in Table 3-6 and the USGS gage at Middle Fork Holston River near Meadowview (03475000).

3.3.5 Water Quality Data

There are very limited amounts of information available on fecal coliform concentrations in Cedar Creek, Hall Creek, Byers Creek, and Hutton Creek. The only published water quality data are included in the Mount Rogers Planning District Commission Report (1991). These measurements of fecal coliform concentrations were collected by the USGS and are listed in Table 3-9. The data indicates that fecal coliform concentrations increase during high flow events and significantly exceed the water quality standard during low flow periods. Since fecal coliform concentrations in every low flow sample (Dec 14, 1987 through Aug 17, 1988) exceeded 200 counts per 100 mL, the water quality standard would not be met without significantly reducing the direct loads to the streams under low flow or dry-weather conditions.

A special study in the four watersheds was conducted by DEQ in 1997. The water quality sampling took place during the winter of 1997 and the spring of 1998. The data collected during that study cannot be used for the development of TMDLs because the fecal coliform analysis did not meet quality control standards. However, the data indicated that fecal coliform violations may still be occurring in the four creeks.

TABLE 3-8
Estimated Flows for Different Return Periods at the USGS Gages
Middle Fork Holston River TMDLs

	Flow (cfs)		
Flow Frequency	**Cedar Creek Near Cedarville, VA (03475602, lat 36 42 53N, long 081 49 51W)**	**Byers Creek Near Glade Spring, VA (03474900, lat 36 44 22N, long 081 47 57W)**	**Hutton Creek Near Chilhowie, VA (03474720, lat 36 46 21N, long 081 43 49W)**
1Q10	0.76	1.91	0.99
7Q10	1.45	3.75	2.29
30Q5	1.68	4.37	2.77
HF 1Q10	1.32	3.39	2.02
HF 7Q10	1.85	4.85	3.14
HM	2.80	7.52	5.40

TABLE 3-9
Fecal Coliform Concentrations Presented in the Mount Rogers PDC Report (1991)
Middle Fork Holston River TMDLs

	Cedar Creek Near Cedarville, VA (03475602, lat 36 42 53N, long 081 49 51W)		Byers Creek Near Glade Spring, VA (03474900, lat 36 44 22N, long 081 47 57W)		Hutton Creek Near Chilhowie, VA (03474720, lat 36 46 21N, long 081 43 49W)	
Date	**Time**	**FC (CFU/100 mL)**	**Time**	**FC (CFU/100 mL)**	**Time**	**FC (CFU/100 mL))**
Dec 14, 1987	1000	5300	0915	600	1200	1700
Feb 03, 1988	1140	K1000	1315	2100	0945	K8400
Apr 19, 1988	1145	3900	1315	57000	0950	23000
Jun 27, 1988	1045	4500	1240	K1400	0900	27000
Aug 17, 1988	1040	2500	1215	2400	0900	6400
May 02, 1989 *	-	K16000	-	3600	-	25000
May 06, 1989 *	-	2700	-	K8600	-	K2500
Jun 17, 1989 *	-	5200	-	K7500	-	26000
Jul 06, 1989 *	-	25000	-	32000	-	23000

* High flow events
K Results based on colony count outside the acceptance range (non-ideal colony counts)

Sampling Sweeps

On December 8 and 9, 1999, DEQ conducted a 2-day sampling event in the watersheds. The objective of the sampling sweeps was to assess water quality conditions at 38 different locations throughout the watersheds to complement the limited data available in the watersheds. The sites for the sweeps were selected to represent a wide range of watershed land uses, to isolate the impacts of sources of pollution, and to evaluate the contributions from individual watersheds. Figure 3-6 shows the location of the sampling sweep sites.

At each site, DEQ staff collected samples near the surface, and at different intervals within the water column. In addition, a bottom sample was collected after the bottom material was disturbed to suspend sediment in the water column. The samples were collected during a dry period with no precipitation recorded in the previous 24 hours. The analysis of the samples was conducted using the most probable number (MPN) method.

Table 3-10 summarizes the information collected during the sampling sweeps.

TABLE 3-10
Sampling Sweeps Information Collected On December 8 and 9, 1999
Middle Fork Holston River TMDLs

Location	Number of Sampling Sites	Fecal Coliform Range (counts/100 mL)
Cedar Creek Watershed	12	20 – 16,000[1]
Hall/Byers Creeks Watershed	12	18 – 16,000
Hutton Creek Watershed	11	18 – 9,200
Dillows Shop & Wash Effluent	1	20
Meadowview Elementary Effluent	1	1700
Emory-Meadowview WWTP Effluent	1	18

[1] Exceeded the limit of the analysis method

Comparisons of the water column samples showed that in 29 of the 38 sites the bottom samples, after resuspension of the bottom sediment by agitation, had higher fecal coliform concentrations than some or all of the samples in the water column. In addition, in four sites the maximum concentration recorded by the MPN method (16,000 counts / 100 mL) was exceeded.

3.4 Assessment of Point Sources and Direct Discharges

Pollutant source data is used to identify and characterize possible sources of fecal coliform. These sources can be classified as point sources and direct discharges, addressed in this section, and nonpoint sources, addressed in Section 3.5. All these different pollutant sources were considered in the development of TMDLs for the four creeks.

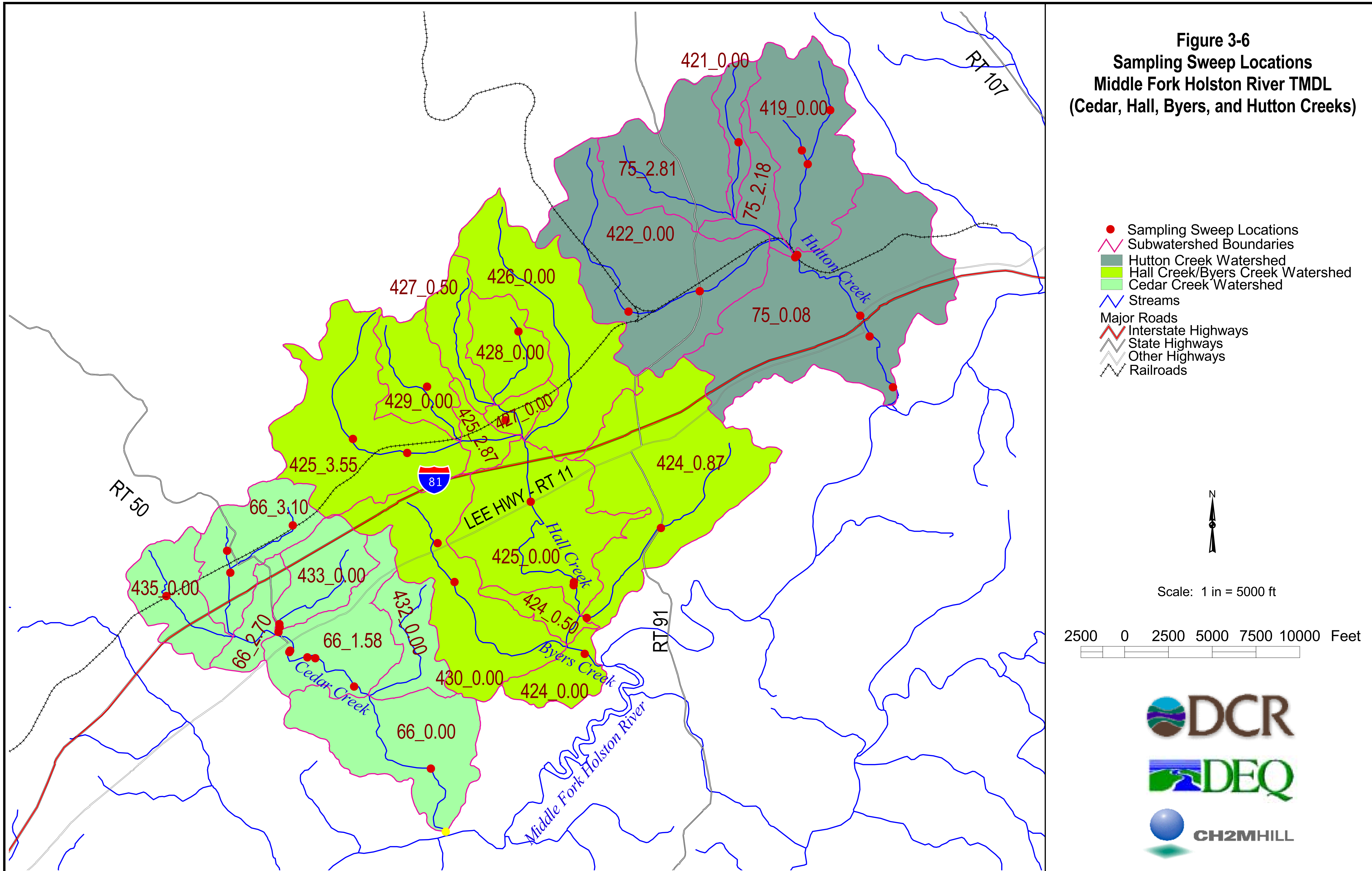


Figure 3-6
Sampling Sweep Locations
Middle Fork Holston River TMDL
(Cedar, Hall, Byers, and Hutton Creeks)
Sampling Sweep Locations
Subwatershed Boundaries
Hutton Creek Watershed
Hall Creek/Byers Creek Watershed
Cedar Creek Watershed
Streams
Major Roads
Interstate Highways
State Highways
Other Highways
Railroads
N
Scale: 1 in = 5000 ft
2500 0 2500 5000 7500 10000 Feet
DCR
DEQ
CH2MHILL
421_0.00
419_0.00
RT 107
75_2.81
75_2.18
422_0.00
Hutton Creek
75_0.08
427_0.50
426_0.00
428_0.00
429_0.00
427_0.00
425_2.87
425_3.55
81
LEE HWY - RT 11
424_0.87
RT 50
66_3.10
425_0.00
Hall Creek
433_0.00
435_0.00
432_0.00
424_0.50
66_2.70
66_1.58
RT 91
Cedar Creek
Byers Creek
430_0.00
424_0.00
66_0.00
Middle Fork Holston River

3.4.1 Permitted Discharges

Point source location data was provided by DEQ Southwest Regional Office. This data also included permitted flows. Only one of the five point sources provided by DEQ was identified in the Basins 2.0 Permit Compliance System (PCS) layer. Two (Patrick Henry High School and Emory & Henry College) of the five permitted facilities ceased to discharge to streams in August 1996 when the Emory-Meadowview Wastewater Treatment Plant began its operation.

Table 3-11 lists all permitted facilities in the Cedar Creek, Hall Creek, and Byers Creek watersheds. There is no point source discharge facility in the Hutton Creek watershed. Discharge Monitoring Reports (DMR) for the three active point sources were provided by the DEQ Southwest Regional Office in January 2000. The DMRs included data on average and maximum flows for December 1999.

Table 3-12 lists the results of fecal coliform samples collected at the active point sources on December 8 and 9, 1999. The effluent from the Meadowview Elementary School had a fecal coliform bacteria count of 1,700 counts/100 mL. Elevated counts of this magnitude are usually not found in a properly operating disinfection unit. DEQ will verify the operation of the disinfection units at the Medowview Elementary sewage treatment plant to ensure that the treated discharge is not contributing to the fecal coliform standard violation in the Cedar Creek watershed. In modeling the fecal coliform count in the stream, the effluent from the school was assumed to be equivalent to the geometric mean water quality standard of 200 counts/100 mL. To assure that the permit condition is being met, DEQ will monitor the effluent monthly for 6 months. If the additional effluent monitoring shows elevated counts, the problem will be addressed through standard inspections and/or enforcement procedures.

TABLE 3-11
Point Source Dischargers in the Hall Creek and Cedar Creek Watersheds
Middle Fork Holston River TMDLs

NPDES	Name	Watershed	Flow (cfs)	Status
VA0026741	Patrick Henry High School	Hall Creek	0.0198	Closed in August 1996-Connected to regional system Emory-Meadowview
VA0024937	Emory & Henry College	Hall Creek	0.1083	Closed in August 1996-Connected to regional system Emory-Meadowview
VA0030589	Meadowview Elem School	Cedar Creek	0.0248	Active system
VA0071366	Dillow's Shop & Wash	Cedar Creek	0.0048	Active system
VA0087378	Emory-Meadowview WWTP	Hall Creek	0.4874	Active system

TABLE 3-12
DMR Flows and Bacteria Data from Sampling Sweep – Point Sources
Middle Fork Holston River TMDLs

Name	Fecal Coliform Outfall Concentration (counts/100 mL)	DMR Monthly Average Discharge (cfs)
Meadowview Elem School	1,700	0.003
Dillow's Shop & Wash	20	0.006
Emory-Meadowview WWTP	18	0.240

3.4.2 Septic Systems

Sewered/Unsewered Areas

The Washington County Service Authority provided three CAD files showing the extent of the sewer coverage in the watersheds. Based on discussions with the Service Authority and their knowledge of the sewer system, an assumption has been made that all residences within 300 feet of a sewer line are connected to that line. All other residences are assumed to be serviced by a septic tank / field system. Using USGS 1:24,000 scale topographic quadrangle maps as a reference, houses were digitized and converted to a GIS layer.

Figure 3-7 shows the location of the sewer areas and the point sources in the watersheds.

Septic Systems

There are no data available for the total number of septic systems in the watersheds. The procedure described above was used to estimate the number of structures served by septic systems.

Table 3-13 summarizes the number of houses connected to septic systems by subwatershed. These numbers were further adjusted to account for changes during the period between the year that the topographic map was prepared and the year for which data was analyzed for calibration or allocation purposes. The adjustments to the number of septic systems in each subwatershed was made proportional to county population estimates provided by the U.S. census data.

Failed Septic Systems

The Mount Rogers Health District provided the numbers of new applications and repairs of septic systems in Washington County during the period 1995-1999. The total number of septic systems (housing units served by septic tanks or cesspool) in Washington County is 13,710 (Source: 1990 US Census Data). Table 3-14 summarizes the number of applications for new septic systems and repairs to existing systems for Washington County and the number of septic systems.

The failure rates, the flows and concentrations associated with failing septic systems is discussed in Section 4, Modeling Approach and Assumptions.

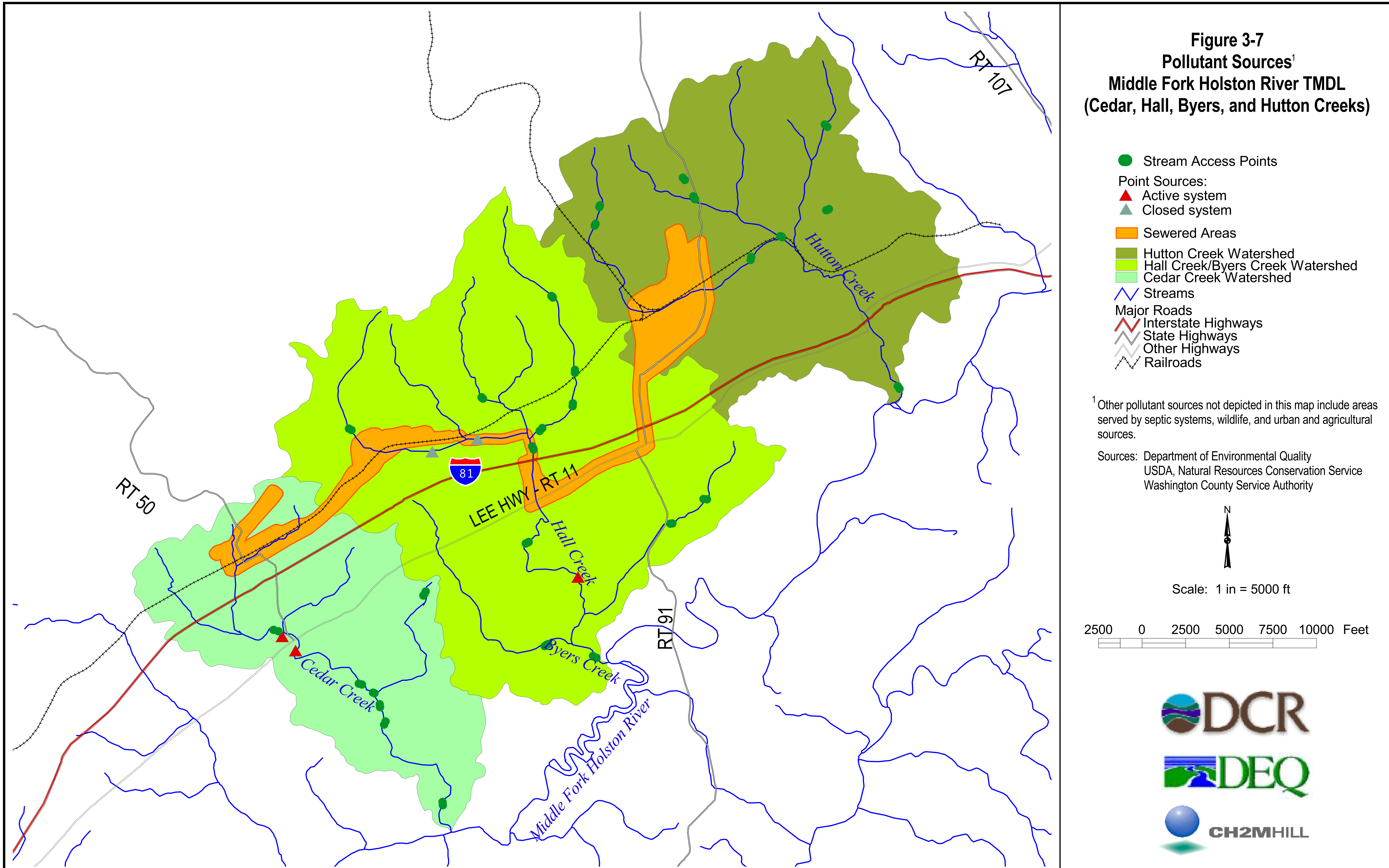


Figure 3-7
Pollutant Sources[1]
Middle Fork Holston River TMDL
(Cedar, Hall, Byers, and Hutton Creeks)

Census Data

Census data was obtained from two sources via the Internet. The two sources are the U.S. Census and the Weldon Cooper Center for Public Service at the University of Virginia. Data gathered includes 1970 and 1990 census data, estimated populations for the years between census counts (1981-89 and 91-99), and projected population for 2010. The majority of the population data gathered was gathered for both Washington and Smyth Counties. More detailed data was available from the 1990 census. The 1990 data was gathered for a block group that is located entirely within the boundaries of the three watersheds. 1990 census data included the total number of residences and the number of residences with septic systems.

TABLE 3-13
Number of Septic Systems by Subwatershed [1]
Middle Fork Holston River TMDLs

Stream	Subwatershed ID	# Septic Systems	Stream	Subwatershed ID	# Septic Systems
Cedar Cr.	432_0.00	13	Hall/Byers Cr.	424_0.00	11
Cedar Cr.	433_0.00	13	Hall/Byers Cr.	424_0.50	5
Cedar Cr.	435_0.00	39	Hall/Byers Cr.	424_0.87	153
Cedar Cr.	66_0.00	73	Hall/Byers Cr.	425_0.00	45
Cedar Cr.	66_1.58	101	Hall/Byers Cr.	425_2.87	18
Cedar Cr.	66_2.70	30	Hall/Byers Cr.	425_3.55	40
Cedar Cr.	66_3.10	23	Hall/Byers Cr.	426_0.00	70
Cedar Cr.	**Total**	**292**	Hall/Byers Cr.	427_0.00	13
			Hall/Byers Cr.	427_0.50	4
Hutton Cr.	419_0.00	67	Hall/Byers Cr.	428_0.00	1
Hutton Cr.	421_0.00	13	Hall/Byers Cr.	429_0.00	22
Hutton Cr.	422_0.00	101	Hall/Byers Cr.	430_0.00	95
Hutton Cr.	75_0.08	71	**Hall/Byers Cr.**	**Total**	**477**
Hutton Cr.	75_2.18	20			
Hutton Cr.	75_2.81	98			
Hutton Cr.	**Total**	**370**			

[1] Source: USGS 1:24000 scale topographic quadrangle maps and sewer maps from the Washington County Service Authority were used to identify structures that are served by septic systems

TABLE 3-14
Number of Applications for New Septic Systems and Repairs in Washington County – 1995 -1998
Middle Fork Holston River TMDLs

Year	New Septic Systems[1]	Repairs[1]
1995	591	76
1996	490	74
1997	586	73
1998	557	52
Average	556	68.75

[1] Personal Communication with L. Scott Honaker III of Mount Rogers Health District (Dec 09, 1999).

3.4.3 Cattle Contribution Directly Deposited Instream

The fecal coliform load from cattle defecating directly into the stream was estimated based on the livestock access zones identified by Kleene (1995), a recent windshield survey conducted by CH2M HILL in December 1999, the number of livestock (dairy cows, beef cows, and dairy heifers when they are not confined) in farms adjacent to the streams and the access points, and BMP information. Livestock access points include but are not limited to stream crossings.

3.5 Assessment of Nonpoint Sources

3.5.1 Urban and Agricultural Sources

Urban and agricultural pollutant sources were developed from land use data, U.S. Department of Agriculture (USDA) agriculture census data, and discussions with local RC&D and NRCS officials.

The agriculture census data was obtained from the USDA web site for Washington County. The agriculture census data was used to estimate the projected growth in the number of farms, agricultural activities, and farm animals.

An estimate of the number of livestock by subwatershed and locations where cattle have access to streams was obtained from the local NRCS office. The number of livestock per watershed was used to estimate manure production. DCR nutrient management specialists and NRCS staff provided information on manure application rates for the different land uses and the number of fecal coliform input directly to the stream.

3.5.2 Grazing animals

Fecal coliform loads from the washoff of fecal deposits during wet weather events were simulated by the model using specified build-up and washoff parameter values. The build-up rate for all pasture land within a subwatershed was calculated based on the following:

- The total number of sheep, horses, beef cows, dairy heifers, and dairy cows in each watershed
- The percent of time each type of livestock is not confined
- The average fecal coliform count discharged by each type of livestock per animal per day

The average fecal coliform count discharged by different animals is estimated using the number of fecal coliform bacteria per 1,000 pounds of each animal type (ASAE, 1994) and the average weight of each animal. The quantity of fecal coliform applied to each land use was calculated based on the density and average daily contribution as shown in Table 3-15.

The distribution of animals by subwatershed is provided in Table 3-16. These data were obtained from NRCS in coordination with DCR and the Holston River Soil and Water Conservation District.

TABLE 3-15
Average Density of Fecal Coliform in the Manure and Average Daily Counts in Wastes of Different Animals
Middle Fork Holston River TMDLs

Animal	Average Weight (lbs)	Fecal Coliform (10^{10} count/1000 lb animal wt/day) (ASAE, 1994)	Contribution of Fecal Coliform (10^{10} count/day)
Dairy Cow	1400[1]	7.2	10.08
Dairy Heifer	1075[2]	7.2	7.74
Beef Cow	1000[3]	13	13.0
Hog	200[3]	8	1.6
Sheep	100[3]	20	2.0
Horse	1000[3]	0.042	0.042

Sources: [1] ASAE, 1994, [2] Bailey and Murphy, 1999; [3] DCR, 1995

TABLE 3-16
Summary of Animal Counts by Subwatershed
Middle Fork Holston River TMDLs

Stream	Subwatershed ID	Beef	Dairy Cow	Dairy Heifer	Horse	Hog	Sheep
Cedar Cr.	432_0.00	175	150	0	0	0	0
Cedar Cr.	433_0.00	50	0	50	0	0	0
Cedar Cr.	435_0.00	200	0	0	0	0	0
Cedar Cr.	66_0.00	450	0	0	0	0	0
Cedar Cr.	66_1.58	150	0	0	0	0	0
Cedar Cr.	66_2.70	50	0	0	0	0	0
Cedar Cr.	66_3.10	130	0	50	0	0	0
Cedar Cr.	**Total**	**1,205**	**150**	**100**	**0**	**0**	**0**
Hall/Byers Cr.	424_0.00	215	0	0	0	0	0

TABLE 3-16
Summary of Animal Counts by Subwatershed
Middle Fork Holston River TMDLs

Stream	Subwatershed ID	Beef	Dairy Cow	Dairy Heifer	Horse	Hog	Sheep
Hall/Byers Cr.	424_0.50	0	0	0	0	0	0
Hall/Byers Cr.	424_0.87	150	300	100	10	0	0
Hall/Byers Cr.	425_0.00	230	0	0	50	0	200
Hall/Byers Cr.	425_2.87	50	0	0	0	0	300
Hall/Byers Cr.	425_3.55	180	0	0	0	0	0
Hall/Byers Cr.	426_0.00	280	0	0	0	0	40
Hall/Byers Cr.	427_0.00	0	0	0	0	0	0
Hall/Byers Cr.	427_0.50	0	0	0	0	0	0
Hall/Byers Cr.	428_0.00	250	0	0	0	0	0
Hall/Byers Cr.	429_0.00	150	0	0	0	0	0
Hall/Byers Cr.	430_0.00	390	0	0	50	0	0
Hall/Byers Creek	**Total**	**1,895**	**300**	**100**	**110**	**0**	**540**
Hutton Cr.	419_0.00	495	0	0	0	200	0
Hutton Cr.	421_0.00	0	0	0	0	0	0
Hutton Cr.	422_0.00	230	200	100	0	0	0
Hutton Cr.	75_0.08	575	0	130	0	0	0
Hutton Cr.	75_2.18	230	0	0	0	0	0
Hutton Cr.	75_2.81	230	0	0	0	0	0
Hutton Cr.	**Total**	**1,760**	**200**	**230**	**0**	**200**	**0**

3.5.3 Manure Spreading

Manure spreading is traditionally conducted on all categories of cropland as a means of adding nutrients to the soil. It is also conducted on certain pasture categories, both as a nutrient supplement associated with pasture improvement and as a means of removing excess manure from the storage facility.

The manure stored for eventual use is generated by beef, heifers, and dairy cattle during periods of confinement. The amount of manure stored is determined by the number of animals in a watershed, the confinement rate for each type of animal, and the fecal output of each type of animal.

Confinement rates and manure spreading schedules are discussed in Section 4, Modeling Approach and Assumptions.

3.5.4 Deer

Both the Virginia Department of Game and Inland Fisheries (DGIF) Southwest Regional Office and the U.S. Fish and Wildlife Service (FWS) local office were contacted in regards to wildlife population data. The FWS only tracks threatened and endangered species which, by the nature of being threatened or endangered, do not have a significant fecal coliform impact on a watershed.

The DGIF provided deer population density estimates for both Washington County (20.1 deer/sq. mile) and for the four watersheds (approximately 30 deer/sq. mile). The Washington County number is based on the annual estimated deer population for the county divided by the area of the county. The watershed number is an estimate based on the experience of the Regional Wildlife Manager, Alan Boyington (1999).

The fecal accumulation rate for deer is discussed in Section 4, Modeling Approach and Assumptions.

3.5.5 Canada Geese

The DGIF also indicated that goose populations, particularly resident Canada geese, may contribute to the fecal loading in the watersheds. This was confirmed in discussions with Gary Boring (1999), RC&D and Fred Copenhaver (1999a), NRCS. However, none of these sources had access to goose population data. Anecdotal evidence suggested there were 100 to 200 geese in the fields at times.

Canada goose population data was obtained from the DGIF Wildlife Information Service via the Internet. DGIF estimates that the resident Canada goose population in Washington county is 100 to 200.

There appear to be no other population estimates for wildlife (raccoon, muskrat, and other mammals) for the county or watersheds.

3.5.6 Dogs

Dog population data for the three watersheds was not available. However, discussions with the Washington County agency responsible for dog licensing, revealed that there are an estimated 3,000 dogs in the county.

3.6 Best Management Practices

Best management practices (BMPs) implemented in the watersheds will reduce fecal coliform loads from agricultural practices.

Estimated fecal coliform removal efficiency for each BMP is listed in Table 3-17.

A large number of agricultural BMPs have been implemented in these watersheds since the mid-1980’s as a result of nonpoint source programs. These programs were led by the Middle Fork Holston River Water Quality Committee and TVA, in cooperation with DCR and implemented by the property owners in the watersheds with assistance from the Holston River Soil and Water Conservation District, the New River Highlands Resource Conservation and Development Area, and NRCS. Many of these BMPs have been installed with funding from Section 319 programs, the Virginia Agricultural Cost-Share Program, the USDA EQUIP Program, and others.

Agricultural BMPs “cover” approximately 1,157 acres (25 percent) of the Cedar Creek watershed; 2,036 acres (20 percent) of the Byers / Hall Creek watershed; and 1,249 acres (17 percent) of the Hutton Creek watershed.

GIS coverage of agricultural BMPs was obtained from DCR. Figure 3-8 shows the location and types of BMPs in the watersheds. This figure does not show the extent of the BMP coverage provided by grazing land protection (SL6) and strip cropping systems (SL3).

BMP data was provided by DCR (Charles Lunsford), RC&D, and NRCS staff (Gary Boring, 1999, and Fred Copenhaver, 1999a).

TABLE 3-17
Typical Fecal Coliform Removal Efficiency for Agricultural Best Management Practices
Middle Fork Holston River TMDLs

Practice Name	Practice Code	Type of Control	Fecal Coliform Removal Efficiency (%)	Fecal Coliform Source	Remark
Reforestation of Erodible Crop and Pastureland	FR-1	Source	-		Land use conversion
Permanent Vegetative Cover on Cropland (State)	SL-1	Source	-		Land use conversion. Planting legumes will not require any manure application. Conversion to pasture will include loads from beef cows.
Grazing Land Protection	SL-6	Source	51 [1]	Calculated from Sheffield, et al (1997)	Structural options include fencing and livestock watering system. Management option includes rotational grazing.
Alternative Water System	SL-6B	Source	82	Calculated from Sheffield, et al (1997)	Keeps livestock away from streams
Animal Waste Control Facility	WP-4	Source	85	USEPA , 1993	Reduces bacteria and nutrients from runoff by storing and applying when needed
Animal Waste Structure Pumping Equipment	WP-4E	Source	-		Maximizes the performance of an Animal Waste Control Facility
Permanent Vegetative Cover on Critical Areas	SL-11	Transport	59	Coyne and Blevins (1995) provided the effectiveness of vegetative filters.	Reduces soil and nutrient loss. Determine the land use type using geographic overlay.
Farm Road or Heavy Traffic animal Travel lane Stabilization	SL-11B	Transport	0		Erosion control only.
Strip Cropping Systems	SL-3	Transport	59 [2]	Estimated	Reduces soil and nutrient loss.
Small Grain Cover Crop for Nutrient Management	SL-8B	Transport	0 [3]		Reduces erosion and leaching of nutrients to ground water. Seasonal.
Stream Crossings & Hardened Access	WP-2B	Transport	0 [4]		Primarily erosion control
Sod Waterway	WP-3	Transport	0 [5]		Reduces erosion and nutrient

[1] According to Sheffield, et al (1997) livestock watering system reduced the average length of time spent by each cow from 12.7 min to 6.2 min per day (51 percent). Removal efficiency of fencing would be much higher where rotational grazing would be lower. Therefore, an average removal efficiency is assumed to 51 percent.

[2] The definition of the BMP (DCR, 1998) suggests that the BMP would function similar to a grass filter in controlling transport of fecal coliform. Coyne and Blevins (1995) found that the average fecal coliform removal efficiency of a 9 meter grass filter was 59 percent (range 43 – 74%). In absence of any published removal efficiency of the particular BMP, the removal efficiency is assumed to be 59 percent.

[3] Small Grain Cover Crop for Nutrient Management is applied during the winter months when there is no liquid dairy manure application to the cropland. Therefore, the removal efficiency is assumed to be 0.0.

[4] Stream Crossings & Hardened Access for livestock and farm vehicles are effective in reducing fecal coliform load only if a stream crossing is built for livestock crossing. Hardened access for livestock would reduce soil loss, but not fecal coliform load. Although the removal efficiency is assumed to be 0.0 for this BMP, the benefit of installing a stream crossing for livestock crossing will be taken into consideration by eliminating the livestock access from the calculation of instream direct deposit made by livestock.

[5] Plant uptake nutrients. For bacteria, the only removal mechanism is filtering and die-off. Plants in waterways will not provide any long term filtering and removal of fecal coliform.

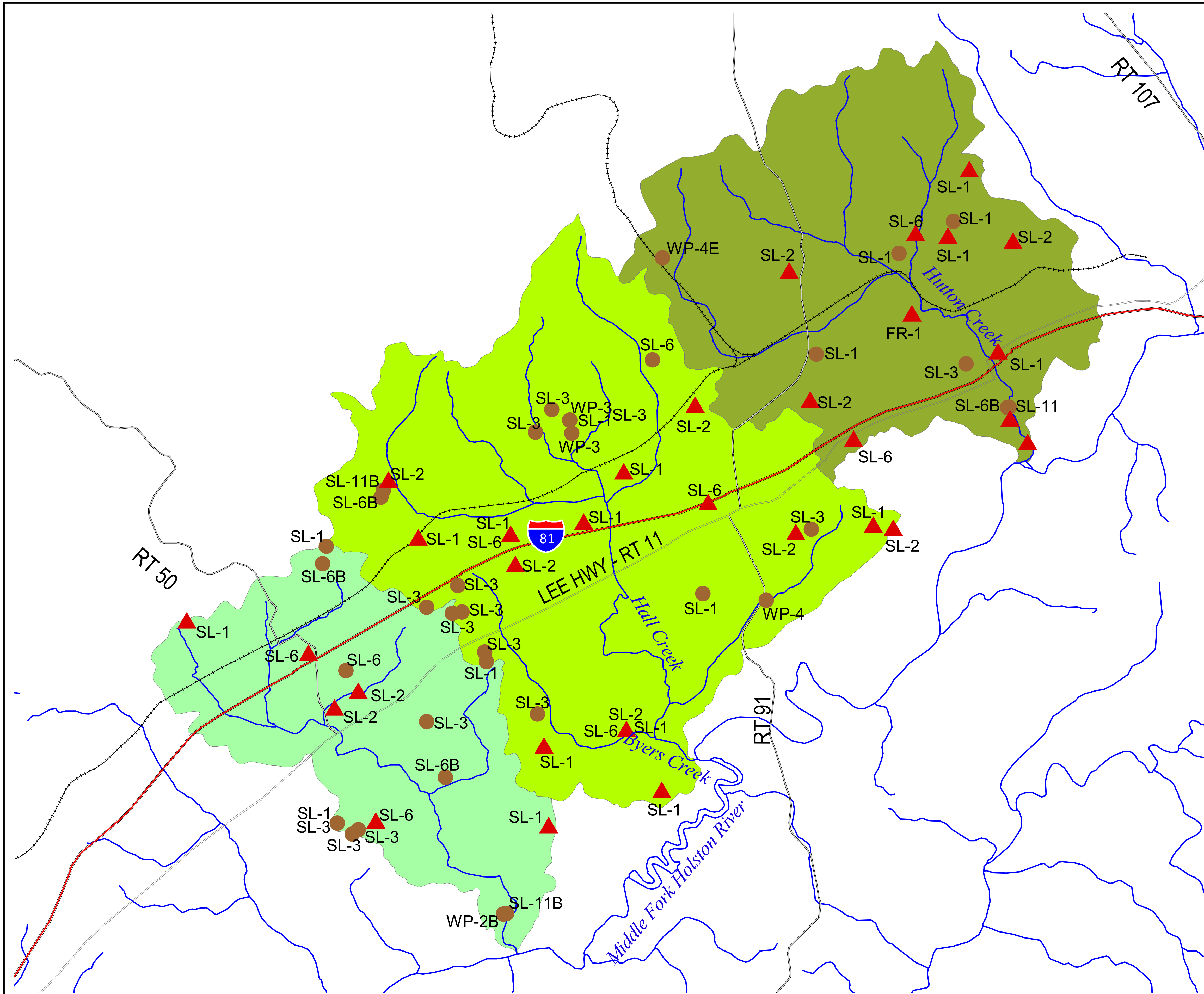


Figure 3-8
Agricultural BMP Locations
Middle Fork Holston River TMDL
(Cedar, Hall, Byers, and Hutton Creeks)

Agricultural BMPs
- DCR
- RCD

Major Roads
- Interstate Highways
- State Highways
- Other Highways
- Railroads
- Streams
- Hutton Creek Watershed
- Hall Creek/Byers Creek Watershed
- Cedar Creek Watershed

NOTE: The full extent of grazing land protection (SL-6) and stripcropping systems (SL-3) are not shown in this figure.

Sources: Department of Conservation and Recreation
Natural Resources Conservation Service
New River Highlands Resource Conservation and Development Area

N

Scale: 1 in = 5000 ft

2500 0 2500 5000 7500 10000 Feet

DCR

DEQ

CH2MHILL

4.0 Modeling Approach and Assumptions

This section describes the detailed approach and assumptions used to characterize the pollutant sources and develop the model input for TMDL analysis in Cedar Creek, Hall Creek, Byers Creek, and Hutton Creek.

4.1 Model and Analysis Tool Selection

Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) version 2.0, a multipurpose environmental analysis system used in regional, state, and local watershed- and water-quality-based studies, was used for TMDL development of the four creeks. BASINS allows rapid assessment of large amounts of point source and nonpoint source data – whether for a single stream or an entire watershed – in an easily used and understood format. The system enhances development of cost-effective methods of environmental protection through incorporation of environmental data, analytical tools, and modeling programs.

HSPF and the Storm Water Management Model (SWMM) are the only two deterministic models that are scientifically defensible, and capable of simulating fate and transport fecal coliform bacteria in storm runoff, as well as in receiving waters, using small time increments. However, HSPF is better suited for non-urban watersheds and natural streams and it was selected for the development of TMDLs for the four watersheds.

4.2 Land Use Classification for Modeling Applications

The land use classification that is available in the GIS coverage provided by the DCR and that were revised to account for changes in land use, as described in Section 3, were further refined to conduct the analysis, modeling, and TMDL development. One or more of the original land uses were grouped into one (new) TMDL class based on the importance of the land use on fecal pollution and the availability of information that will allow the development of a distinct set of land use specific parameter values for the model.

The TMDL land use classification and the corresponding original land uses are listed in Table 4-1. The table also includes the percent pervious for each new land use and the corresponding references.

The land use coverage does not include any information about feedlots, barnyards, loafing areas, and farmstead in agricultural areas. There was no explicit consideration of these areas in the model setup. However, impervious areas of different land uses were explicitly considered in the model and were calculated by dividing total land use areas into pervious and impervious areas based on the percentages presented in Table 4-1.

TABLE 4-1
Land Use Classification and Percent Perviousness
Middle Fork Holston River TMDLs

TMDL Classification	Original Classification	Percent Perviousness	Reference
Forest	Forest; Reclaimed Forest; Low Brush	98	NVPDC, 1994; Center for Watershed Protection, 1998
Improved Pasture	Improved Pasture	98	NVPDC, 1994; Center for Watershed Protection, 1998
Hayfield	Improved Pasture, Hayfield	98	NVPDC, 1994; Center for Watershed Protection, 1998
Overgrazed Pasture	Overgrazed Pasture; Overgrazed Pasture, Gullied	98	NVPDC, 1994; Center for Watershed Protection, 1998
Poor Pasture	Poor Pasture, Gullied; Poor Pasture, little cover; Unimproved Pasture	98	NVPDC, 1994; Center for Watershed Protection, 1998
Field Crop	Field Crop	98	NVPDC, 1994; Center for Watershed Protection, 1998
Row Crop	Row Crop; Row Crop Gullied	98	NVPDC, 1994; Center for Watershed Protection, 1998
Strip Crop	Row Crop Strip	98	NVPDC, 1994; Center for Watershed Protection, 1998
Built-up Areas	Urban Land: Built-up area; Residential; Residential Trailer Park	75	TR-55 (SCS, 1986)
Disturbed Area	Disturbed Area	98	NVPDC, 1994; Center for Watershed Protection, 1998
Water	Water	0	

4.3 Stream Geometry

CH2M HILL estimated cross sectional data for six stream reaches (two in the Cedar Creek watershed and four in the Hall Creek / Byers Creek watershed) in December 1999. This data (bottom width, base flow depth, bank full depth, channel side slope, and extent of flood plain) and topographic data were used to prepare depth-flow tables for the six reaches. Cross sectional areas were calculated assuming channel shapes are trapezoidal. Flow (Q) was calculated using Manning's equation. Channel slopes were calculated using reach length and elevation change obtained from USGS quad sheets. Manning's roughness coefficient (n) was assumed to be 0.05 for every reach. According to Chow (1959), the roughness coefficient for most minor natural streams varies from 0.03 to 0.07. Horizontal areas and storage volumes were then calculated, based on depth and channel slope.

The remaining reaches that have similar characteristics to one of the previously calculated reaches were classified as equivalent reaches. Similar characteristics that were evaluated include drainage area, reach length, and channel slope. Equivalent reaches were assumed to have the same cross sectional characteristics as one of the original reaches. This resulted in geometry calculations for an additional 16 reaches. Stream geometry for the remaining 26 reaches were calculated by determining relationships between drainage area, flow, and depth at each of the three stages. The underlying assumption in developing the relationships is that the slope and the roughness do not vary significantly among the reaches. The original six reaches provided the data. Table 4-2 is a summary of the relationships and the corresponding R-Squared values used for the remaining calculations.

TABLE 4-2
Stream Geometry Relationships
Middle Fork Holston River TMDLs

Y - Variable	Stage	Relationship[1]	R-squared
flow depth (ft)	Base	y = 0.4287exp(0.0001x)	0.6906
flow depth (ft)	TOB	y = 1.776exp(0.0001x)	0.8276
flow depth (ft)	TOFP	y = 8.7317exp(0.0001x)	0.7381
flow (cfs)	Base	y = 1.6585exp(0.0004x)	0.9917
flow (cfs)	TOB	y = 17.175exp(0.0004x)	0.7624
flow (cfs)	TOFP	y = 7808.1exp(0.0004x)	0.5482

[1] x = drainage area.

Cross sectional areas and horizontal areas were assumed proportional to the corresponding properties of the next downstream reach (observed or equivalent based on drainage area). See Appendix A for summaries of stream geometry for the Cedar, Hall, Byers, and Hutton Creek watersheds and the watershed for the Middle Fork Holston River upstream of Groseclose.

4.4 Permitted Sources

Fecal coliform concentration data from point source discharges were not available from any source, including previous studies, investigations, and point source discharge permits. After consulting with DEQ, CH2M HILL used representative fecal coliform concentrations for the discharges from Meadowview Elementary School, Emory & Henry College, and Patrick Henry High School. Fecal coliform concentrations in effluent from Dillow’s Shop & Wash and Emory-Meadowview WWTP were assumed to be the same as the concentrations measured during the December 8-9, 1999 sampling sweep. A concentration of 200 counts/ 100 mL were to be assumed for the Meadowview Elementary School and for the two inactive permitted sources. All of the above concentrations were used for model validation purposes.

A fecal coliform concentration of 200 count/100 mL was used for all point sources in all allocation scenarios. Flows from the three active permittees were assumed to be equal to the average flows reported in the December, 1999, DRMs for each source. Inactive plant flows were assumed to be the maximum allowed by permit for the model runs that included these facilities while they were active.

4.4.1 Septic Systems

The calculation of failure rates depends on the data available. Unfortunately, there is no long term information on the number of septic systems or their failure rate. The following is a brief description of the efforts undertaken to develop an estimate of failure rates for septic systems in the four watersheds.

The failure rate was originally calculated by dividing the number of repair applications by the total number of systems. For example, assuming an annual increase of 556 septic systems in Washington County, the total number of septic systems at the beginning of 1995 was approximately 16,525. The resulting average failure rate of septic systems in Washington County would be 0.40 percent. This failure rate seemed to be at the low end of the range as it only accounted for the reported and repaired systems in the county.

The National Small Flows Clearinghouse (NSFC) has published a document (NSFC, 1993) summarizing local and state health department responses to a nationwide questionnaire. The data is summarized on a state by state basis and details individual counties and health districts. Washington County is listed as not responding. It is clear from the data that most health departments in the state reported only the failures for which repair permits were issued. Failure rate estimates were not part of the survey and the data in the summary, according to NSFC staff, does not support calculations of failure rates.

The alternative method for calculating failure rates involves the average life of a septic system in Washington County. Once this has been determined, the failure rate is calculated by determining the probability of a system failing in any given year of its projected life. The average life of a septic system is influenced by many factors, including the design life of the tank and periodic maintenance (or lack of maintenance). For example, if the average life of a septic system is 50 years, then the probability of it failing in any given year would be 1/50years or 0.02 failures/year. The failure rate for this probability would be 2 percent. Based on conversations with local health department personnel (Honaker, 2000b), an average life of 25 years is a reasonable assumption for Washington County. This results is a failure rate of 4 percent. This failure rate was used in the development of the TMDLs for the four watersheds. It was assumed that the estimated failure rate is applicable during the entire modeling period 1985-2015.

The flow rate for septic discharge is 75 gallons per day per person (VAC, 1999). The typical fecal coliform concentrations are 1×10^4 count/100 mL in septic overcharge (Horsley & Witten, 1996) and 1×10^4 to 1×10^5 count/100 mL in raw sewage (Metcalf and Eddy, 1991). It was assumed that the representative concentration for septic overcharge as 1×10^4 count/ 100 mL which is the low end of the range to account for die-off of bacteria during transport to the receiving water.

The number of septic systems in each subwatershed was calculated in the following method. Structures (houses) were digitized from the appropriate USGS 1:24,000 topographic quadrangle maps for the watersheds, as described in Section 3. The maps were last updated in 1969. It was assumed that the number of houses changed very little between the 1969 and the 1970 census. This represents the baseline number of houses in each subwatershed. The number of houses in 1988 (midyear of water quality calibration) for each watershed was calculated by first excluding houses from five subwatersheds that were assumed to be attached to the Glade Spring WWTP. This is in accordance with the assumption that houses outside the sewered areas will discharge wastes to septic systems. The increase in the number of houses in any given year is assumed to be proportional to the increase in population. The adjusted numbers were then increased proportionally to the population increase between 1970 and 1988 for the entire county based on the 1970 U.S. census and the 1988 U.S. census estimate (U.S. Bureau of the Census, 1982 and 1992).

The number of septic systems per subwatershed for 1999 and 2010 were calculated in a similar manner. The exception is that the baseline house data was further adjusted to account for the creation and expansion of the Emory-Meadowview WWTP. The number of adjusted houses with septic data was then increased proportionally to the population increases based on the 1999 population estimate and 2010 population projection provided by the Virginia Employment Commission and Weldon Cooper Center for Public Service respectively (VEC, 2000, and Weldon Cooper Center, 1999).

The fecal coliform load from failed septic systems in each subwatershed was calculated using the number of septic systems, septic system failure rate, the concentration of fecal coliform in septic outflow, the flow rate from the failed systems, and the average size of the household in the unsewered areas.

Tables for each year (1988, 1999, and 2010) showing subwatershed, number of failed systems, flow / day (based on 1 person / septic), fecal load / day (based on 1 person / septic) are provided in Appendix B. Flows and fecal loads will increase proportionally to the number of people per septic system. Based on the 1990 census, there are approximately 4.8 people living in each residence served by a septic system (U.S. Bureau of the Census, 2000).

4.4.2 Cattle Contribution Directly Deposited Instream

Cattle with access to a stream have direct contributions of fecal coliform. The identification of discrete livestock access points facilitates the analysis of direct contributions. Livestock access points (or zones) were identified based on a previous study of the watersheds (Kleene, 1995), input from NRCS, RC&D, and Soil and Water Conservation District staff, and recent watershed visits conducted by CH2M HILL (December 1999).

Access point locations were entered into the GIS as a separate layer and compared to the locations of the animals counts identified in each subwatershed. The animals were considered to be associated with a given access point when they met the following two criteria:

- The animal locations were identified to be in close proximity to an access point (zone) based on information provided by NRCS and RC&D staff; and
- No additional stream reach was identified between the animal locations and the access point.

Literature values provide the amount of time each cow spends instream and the impact of BMPs (e.g., livestock watering system) in reducing the loads. According to Sheffield, et al

(1997), the average time spent per cow in the stream area is 12.69 minutes/day. After installation of a livestock watering system as an alternative source of water, the average time spent per cow in the stream area was reduced to 6.19 minutes/day. The stream area was defined as the distance from the center of the stream to a point approximately two cow lengths (4.9 meters or 15 ft). This results in a cross sectional length of 30 feet. Assuming a stream width of 2.5 feet results in each cow spending an average of 1/12 of the original time or 1.06 min/day in the stream. This assumption was discussed and validated with Sheffield (2000).

The number of each type of livestock was weighted by the confinement rates assigned to each animal type. The number of animals available to an access point was further weighted to account for the seasonal differences in temperature and the time a typical animal would spend in the stream. The Virginia Cooperative Extension has published a pamphlet that discusses the total water intake of cows (Hall, 1999). This document lists the gallons of water per pound of dry matter required for temperatures ranging from 40 to 90 degrees F. The data was plotted and a relationship was determined for temperature and water consumed per animal. Monthly ratios were calculated based on the mean temperature for each month. Further analysis revealed that the original data for the 12.69 min/animal/day was collected in the time frame of November to January. An average ratio for these three months was determined to be 0.344 gallons of water/lb. dry matter. The final correction factor for temperature was calculated as a ratio of the monthly ratio divided by 0.344. Each correction factor was applied to the confinement rate weighted number of animals at each access point for each month.

The average time spent per cow in the stream was multiplied by the number of beef cows, dairy cows, and dairy heifers for each access point. The result was the average number of hours that each of the three livestock types spent in the stream at or around the access points. The number of hours was then divided by 24 and multiplied by the fecal coliform production rate previously calculated. Summing the total fecal coliform deposited in the stream for the three livestock types results in total fecal coliform deposited at each stream access points (counts/day).

Table 4-3 presents the number of cows that have direct access to the stream and Table 4-4 presents the number of hours per day that these cows spend in the stream. These data are presented on a monthly basis for each watershed.

4.5 Nonpoint Sources

Buildup and washoff of pollutants on urban areas and in agricultural areas are physically-based approaches incorporated in the HSPF model. Buildup (accumulation rate) refers to all of the complex spectrum of dry-weather processes that deposit or remove pollutants between storms. Examples of these processes include deposition, dry fall, street cleaning, manure spreading, etc. These processes lead to an accumulation of material associated with solids which are then “washed off” during storm events. HSPF also accounts for bacteria die-off with a component for pollutant decay transformation. Even though the true physics of pollutant transport are poorly understood and there are many variables that impact the transport, a well calibrated model provides good approximations of the pollutant loads resulting form these processes.

TABLE 4-3
Monthly Number of Cows with Access to Streams, Adjusted for Temperature Variations
Middle Fork Holston River TMDLs

Watershed	January	February	March	April	May	June	July	August	September	October	November	December
Beef Cows												
Cedar Creek	421.1	445.5	873.7	997.8	1143.3	1299.1	1372.3	1354.2	1231.9	1022.9	870.8	451.5
Hall/Byers Creek	594.9	629.5	1234.4	1409.8	1615.3	1835.6	1938.9	1913.3	1740.6	1445.3	1230.3	637.9
Hutton Creek	198.3	209.8	411.5	469.9	538.4	611.9	646.3	637.8	580.2	481.8	410.1	212.6
Dairy Cows												
Cedar Creek	54.3	57.5	67.6	115.9	132.8	150.9	159.4	157.3	143.1	118.8	101.1	58.3
Hall/Byers Creek	72.4	76.6	90.2	154.5	177.0	201.2	212.5	209.7	190.8	158.4	134.8	77.7
Hutton Creek	72.4	76.6	90.2	154.5	177.0	201.2	212.5	209.7	190.8	158.4	134.8	77.7
Dairy Heifers												
Cedar Creek	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hall/Byers Creek	54.3	57.5	112.7	128.7	147.5	167.6	177.1	174.7	159.0	132.0	112.4	58.3
Hutton Creek	70.6	74.7	146.6	167.4	191.8	217.9	230.2	227.2	206.6	171.6	146.1	75.7

TABLE 4-4
Time Spent by Cows in Stream – Units: hours/day
Middle Fork Holston River TMDLs

Watershed	January	February	March	April	May	June	July	August	September	October	November	December
Beef Cows												
Cedar Creek	7.42	7.85	15.40	17.59	20.15	22.90	24.19	23.87	21.71	18.03	15.35	7.96
Hall/Byers Creek	10.49	11.09	21.76	24.85	28.47	32.35	34.17	33.72	30.68	25.47	21.68	11.24
Hutton Creek	3.50	3.70	7.25	8.28	9.49	10.78	11.39	11.24	10.23	8.49	7.23	3.75
Dairy Cows												
Cedar Creek	0.96	1.01	1.19	2.04	2.34	2.66	2.81	2.77	2.52	2.09	1.78	1.03
Hall/Byers Creek	1.28	1.35	1.59	2.72	3.12	3.55	3.75	3.70	3.36	2.79	2.38	1.37
Hutton Creek	3.75	1.28	1.35	1.59	2.72	3.12	3.55	3.75	3.70	3.36	2.79	2.38
Dairy Heifers												
Cedar Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hall/Byers Creek	0.96	1.01	1.99	2.27	2.60	2.95	3.12	3.08	2.80	2.33	1.98	1.03
Hutton Creek	1.24	1.32	2.58	2.95	3.38	3.84	4.06	4.00	3.64	3.02	2.57	1.33

Figure 4-1 shows a schematic representation of the buildup and washoff processes described above. A more detailed description of each process is presented in Appendix C.

4.5.1 Livestock Grazing

Fecal coliform accumulation rates were calculated by first applying the time spent grazing in pasture (based on the monthly confinement rate) for each animal type. The resulting number of animals were added up by watershed and each sum was divided by the area of pasture and improved pasture in the watershed, resulting in the number of each type of animal per acre by month. The number of animals per acre was multiplied by the number of fecal coliforms produced per animal per day, resulting in the fecal coliform accumulation rate attributable to grazing livestock in pasture and improved pasture.

4.5.2 Land application of manure

The following assumptions regarding liquid dairy manure application are based on discussions with Dean Gall, Nutrient Management Specialist, Dublin, VA (January 7, 2000 and February 3, 2000) and Wayne Turley, Conservation Specialist, NRCS, Abingdon, VA (January 18, 2000). These assumptions were further refined with input from DCR (Lunsford 2000a and 2000b).

- Manure is applied to cropland (i.e., field crop, row crop, and strip crop), improved pasture, and hayfields.
- All of the manure produced in each watershed is applied within the watershed. No manure is "exported" outside of the watershed.
- Manure is not spread on fields exceeding 20 percent slope. However, a GIS analysis revealed that less than 5 percent of the cropland in any watershed has slopes greater than 20 percent. Additionally, the lack of 180-day manure storage capacity increases the likelihood that manure is spread on fields with slopes exceeding 20 percent. This is due to the assumed preference of farmers to evenly distribute excess manure to the maximum extent possible.
- On average, dairy farms spread 7,000 gallons of liquid dairy manure or 20 tons of semi-solid manure per acre.
- Dairy cows, dairy heifers, and beef cows spend the unconfined periods in pasture areas.

Manure application rates vary seasonally. Monthly manure application rates are based on the confinement rates presented in Table 4-5. The manure application schedule used in the development of the TMDLs is presented in Table 4-6.

Fecal Coliform Accumulation Rate Development

Summary of Fecal Coliform Sources

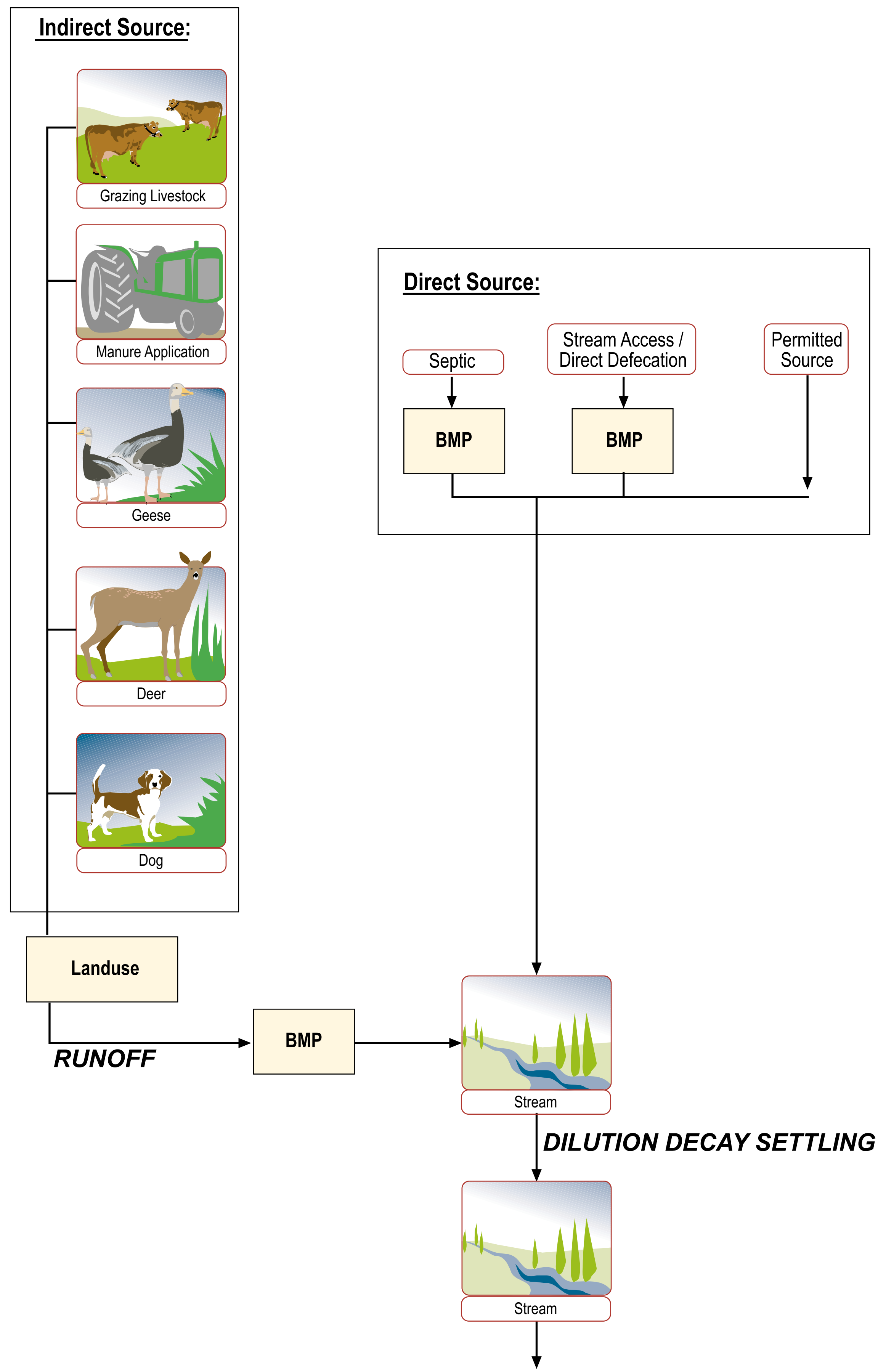


TABLE 4-5
Animal Confinement Rates
Middle Fork Holston River TMDLs

Animal	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Beef	40%	40%	0%	0%	0%	0%	0%	0%	0%	0%	0%	40%
Dairy Cow	60%	60%	60%	40%	40%	40%	40%	40%	40%	40%	40%	60%
Dairy Heifer	40%	40%	0%	0%	0%	0%	0%	0%	0%	0%	0%	40%
Horse	65%	65%	65%	30%	30%	30%	30%	30%	30%	30%	65%	65%
Hog	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Sheep	0%	0%	20%	0%	0%	0%	0%	0%	0%	20%	0%	0%

Source: DCR, NRCS

Table 4-6 summarizes the allocation of manure to cropland, improved pasture, and hayfield on a monthly basis.

TABLE 4-6
Monthly Manure Application Schedule for Cropland, Improved Pasture, and Hayfield
Middle Fork Holston River TMDLs

Month	% of Annual Manure Generated by Confined Livestock Available for Spreading	% of Total Spread on Cropland	% of Total Spread on Improved Pasture & Hayfield
January	5	0	5
February	5	0	5
March[1]	10	7.5	2.5
April	20	20	0
May	10	10	0
June	5	0	5
July	10	0	10
August	5	0	5
September	5	5	0
October	10	10	0
November	10	10	0
December[1]	5	3.75	1.25
Total	100	66.25[2]	33.75[2]

1 Only in March and December was manure spread on both cropland and improved pasture & hayfield. % of Total allocated in a 75%:25% ratio of cropland to improved pasture & hayfield.
2 Ratio of manure spread on cropland to manure spread on improved pasture & hayfield is significantly less than 75-80% cropland stated in source document.
Source: Charles Lunsford, DCR, Revised Information on Animal Counts, Confinement Rates, and Manure Applications and BMPs installed in Hutton, Cedar, and Hall/Byers Watersheds, 2/17/00

4.5.3 Land Application of Poultry Litter

No poultry farms have been identified within the four watersheds in the study area.

4.5.4 Deer

The fecal coliform accumulation rate for deer was calculated by converting the number of deer per square mile to the number of deer per acre and multiplying by the total fecal coliform output per deer per day (Halls, 1984). This resulted in 3.26 x 10^8 counts/ac/day due to deer.

4.5.5 Canada Geese

Canada geese were assumed to be in one large flock of 200 birds residing exclusively in the Hall/Byers Creek watershed. The fecal coliform accumulation rates were calculated by multiplying the fecal coliform generation rate (counts/animal/day) by the 200 members of the flock, resulting in a total generated per day (counts/day). It was assumed that the geese would only be found on pasture and improved pasture in the summer months (April through October) and on the same land use and cropland in the winter months (November through March). Fecal accumulation rates were calculated for the two periods by dividing the total generated per day by the area of the land uses assumed above. Table 4-7 summarizes the fecal accumulation rates attributable to Canada geese.

TABLE 4-7
Fecal Coliform Accumulation Rate - Units: 10^6 count/ac/day
Source: Canada Geese
Middle Fork Holston River TMDLs

Stream	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cedar Cr.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hall/Byers Cr.	24.7	24.7	24.7	28.6	28.6	28.6	28.6	28.6	28.6	28.6	24.7	24.7
Hutton Cr.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4.5.6 Dog

Dog populations in the three watersheds were assumed to be proportional to the number of residences in the watersheds. Based on census data and the number of dogs in Washington County, it was assumed that there are 0.142 dogs per house. Since the number of houses in each subwatershed was estimated for the septic system calculations, the number of dogs was calculated for two residential densities, built-up areas, and for all other areas. The latter was necessary due to the large number of houses identified outside the built-up areas.

Dog fecal coliform generation was estimated at 1.15 x 10^{10} counts/animal/day. This was based on the number of fecal coliforms per gram of dog feces (Kadlec and Knight, 1994) and an average fecal production rate of 500 g/dog/day. This generation rate was applied to the two land use categories across the entire three watersheds. Table 4-8 summarizes the results of fecal coliform accumulation rates for dogs.

TABLE 4-8
Fecal Coliform Accumulation Rate
Source: Dogs
Middle Fork Holston River TMDLs

Land Use	Fecal Coliform Accumulation Rate (counts/ac/day)
Built-up	2.472E+08
Other[1]	1.163E+08

[1] All other land uses.

4.6 Approach to Account for Growth

The Comprehensive Plan for Washington County was originally developed in 1978 and the last major update was completed in 1986. Since then, minor updates have taken place to meet the Commonwealth's 5-year update requirements. According to Mr. Mark Reeter, County Administrator, the county is currently in the process of selecting a consultant to conduct a complete update of the plan, but the process will not start until July of 2000. According to county officials, the current Comprehensive Plan is not representative of the future of the county. Under the direction of the county Administrator, the county's Planning and Zoning Official (Cathy Freaman) and the Building Official (Bill Cole) maintain information on the plan updates and building development.

The county's current population is approximately 49,400 people. The population is concentrated along Route 11 and Interstate 81 in the Bristol – Abingdon corridor, in and around Abingdon, and between Abingdon and the Smyth County line. The best population projections are based on census data and were used in the development of the TMDL for the four creeks.

The county has land use record and tax maps but they do not regularly update the maps. Washington County is currently developing a GIS and a digital tax-base mapping system; however, the electronic version is not expected to be available during this project.

4.7 Model Calibration

This section describes the approach and results of model calibration and validation. Model calibration involves comparing the model results with observed data and improving the accuracy of model results for a given set of conditions. A calibrated watershed model is a credible tool for simulating hydrology and the fate and transport of water quality constituents. Model validation augments the credibility of the model by simulating and comparing model results with a different set of observed data.

The objective of the modeling effort was to develop calibrated and validated watershed models for Cedar, Hall / Byers, and Hutton Creeks. The report on Water Quality Monitoring on the Middle Fork Holston River in Smyth and Washington Counties (Mount Rogers Planning District Commission, 1991) includes nine samples at each of Cedar, Byers, and Hutton Creeks between 1987 and 1989. Both instantaneous flow and fecal coliform concentration were measured during the sampling. These data are inadequate for hydrologic and water quality calibration of the model.

Given the lack of data available in the watersheds, a “paired watershed” approach was used for model calibration and validation. In the paired watershed approach, a different watershed is selected for model calibration such that the hydrologic conditions, terrain, land uses, and pollutant sources are similar to those of the Cedar, Hall/Byers, and Hutton Creek watersheds. An appropriate paired watershed was determined near Groseclose at the headwaters of the Middle Fork Holston River after thoroughly reviewing available data.

The purpose of model calibration is to compare the model results with observed data and to improve the accuracy of model results for a given set of conditions. A calibrated watershed model is a credible tool for simulating hydrology and the fate and transport of water quality constituents. The model calibration, validation, and application sites do not have to be in the same watershed, but within a spatial domain that defines a range of spatial conditions to which a calibrated and validated model can be successfully applied without further adjustment of parameter values.

Figure 4-2 shows the geographic location of the watersheds, stream network, flow gages, water quality monitoring stations, and weather stations.

The model calibration process involves hydrologic calibration and water quality calibration.

4.7.1 Hydrologic Calibration

Hydrologic calibration combines the physical characteristics of the watershed and the observed meteorological data to produce the simulated hydrologic response. All watersheds have similar hydrologic components, but they are generally present in different combinations; thus, different hydrologic responses occur on individual watersheds. HSPF simulates runoff from four components:

- Surface runoff from impervious areas directly connected to the channel network
- Surface runoff from pervious areas
- Interflow from pervious areas
- Groundwater flow

Since the historic stream flow or land surface runoff data are not divided into these four units, generally the relative relationships among these components are inferred from the examination of many events over several years of continuous simulation.

Due to lack of long-term flow data in the Cedar, Hall, Byers, and Hutton Creeks, a nearby watershed (located near Groseclose) was selected for hydrologic calibration of the model. The Groseclose site has long-term flow data recorded by USGS. In addition, the suitability of the hydrologic calibration at the Groseclose site for the models at the Cedar Creek, Hall Creek, Byers Creek, and Hutton Creek watersheds was assessed based on the similarity in hydrologic characteristics of the watersheds.

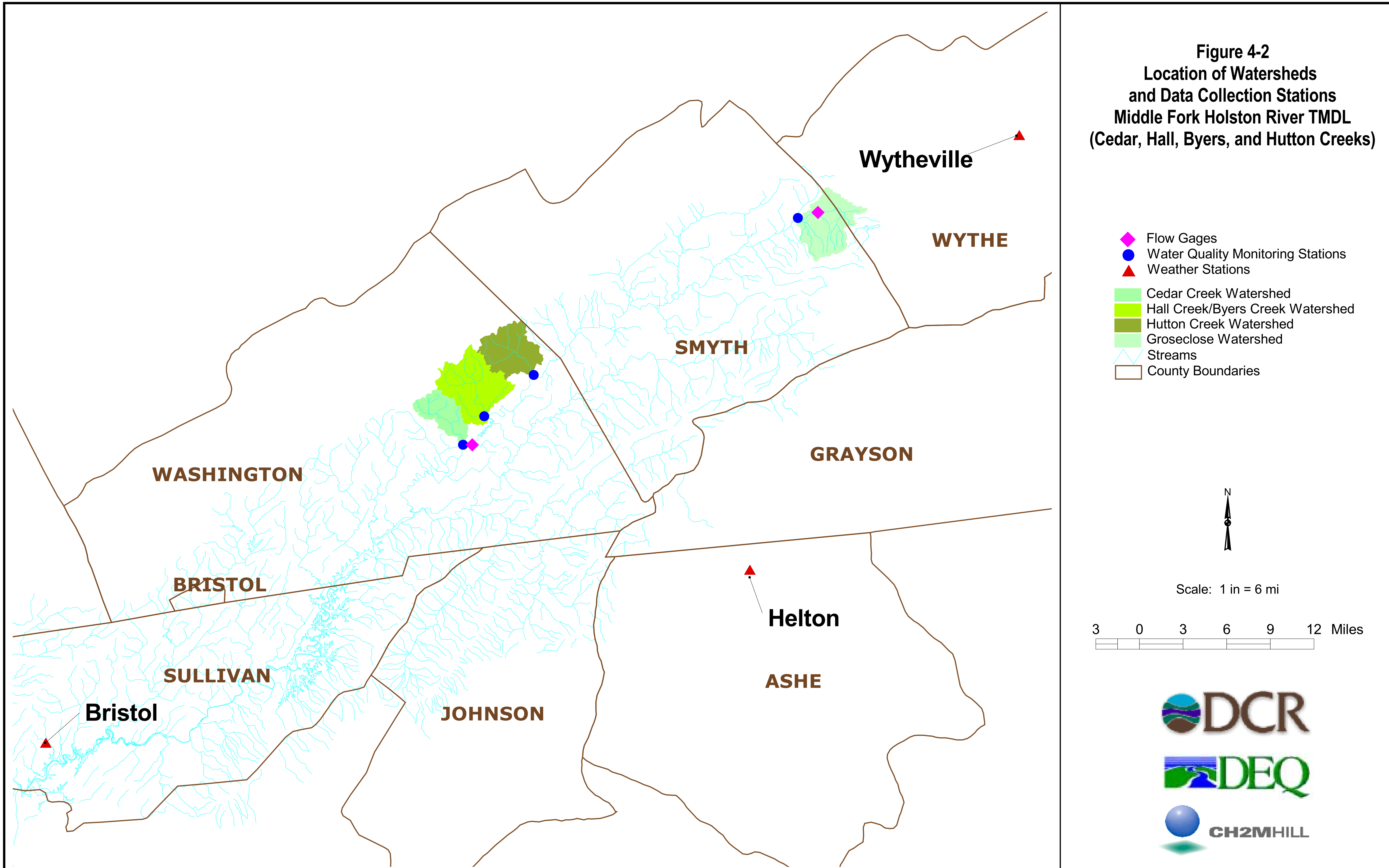


Figure 4-2
Location of Watersheds
and Data Collection Stations
Middle Fork Holston River TMDL
(Cedar, Hall, Byers, and Hutton Creeks)
Flow Gages
Water Quality Monitoring Stations
Weather Stations
Cedar Creek Watershed
Hall Creek/Byers Creek Watershed
Hutton Creek Watershed
Groseclose Watershed
Streams
County Boundaries
N
Scale: 1 in = 6 mi
3 0 3 6 9 12 Miles
Wytheville
WYTHE
SMYTH
GRAYSON
WASHINGTON
BRISTOL
SULLIVAN
JOHNSON
ASHE
Helton
Bristol
DCR
DEQ
CH2MHILL

Table 4-9 (Bisese, J. A., 1995) shows a comparison of hydrologic characteristics of the watershed with characteristics of the Hutton Creek, Hall / Byers Creek, and Cedar Creek watersheds. In particular, the characteristics of Hutton Creek and Hall / Byers Creek watersheds resemble those of Middle Fork Holston River at Groseclose watershed.

As listed in Table 4-9, forest cover and channel slope varied significantly in the four watersheds. J. A. Bisese (1995) developed regression equations for estimating the magnitude and frequency of peak discharges of rural, ungaged streams in Virginia and considered the values specified in the table as within the range of conditions valid for applicability of the regression model. Forest cover and channel slope were not explicitly considered in the regression model. In the HSPF model, channel slope and forested cover are input parameters and the model successfully simulates hydrologic conditions for natural streams with varying slopes (channel slopes for all four watersheds were less than 1.56 percent) and any range of forest conditions. Therefore, the Groseclose watershed adequately represents the four watersheds for purposes of HSPF model calibration.

The USGS gage (Station ID 03473500) near Groseclose recorded daily flow data from October 1, 1987 through September 30, 1989. Also, thirty-two fecal coliform samples were collected during 1992-1998 at a location (Agency 21VASWCB, Station ID 6CMFH053.36) approximately 2 miles downstream from the USGS gage.

TABLE 4-9
Comparison of Hydrologic Characteristics of Project Watersheds (Bisese, J. A., 1995)
Middle Fork Holston River TMDLs

Station Number	Station Name	Peak Discharge Region	Drainage Area (sq. miles)	Main Channel Slope (ft/ mile)	Main Channel length (mile)	Mean Basin Elevation (feet)	Forest Cover (percent plus one)	Mean Annual Precip. (inch)	24 hour, 2 year rainfall (inch)
03473500	MF Holston River at Groseclose	Southern Valley and Ridge (SV)	7.39	46.2	3.6	2,710	49	39.0	2.69
03474700	Hutton Creek near Chilhowie	SV	8.32	82.1	3.7	2,230	22	43.0	2.50
03474800	Hall Creek near Glade Spring	SV	7.9	68.2	4.4	2,110	25	43.5	2.55
03475600	Cedar Creek near Meadowview	SV	3.38	65.9	2.2	2,610	6	44.4	2.72

The model was setup for the Groseclose watershed and calibrated using the flow data at the gaging station known as M F Holston River at Groseclose, VA (Station ID 03473500). The following steps were used in conducting the hydrologic calibration of the watershed models:

1. Estimated individual values for all parameters
2. Performed hydrologic calibration run for October 1, 1987 through September 30, 1989
3. Compared simulated flows for the Reach “06010102 36 6.15” with observed flow data at the USGS gage (ID 03473500)

4. Adjusted hydrologic calibration parameters, and initial conditions as necessary, to improve agreement between simulated and literature values

5. Repeated steps 2, 3, and 4 until satisfactory agreement was obtained

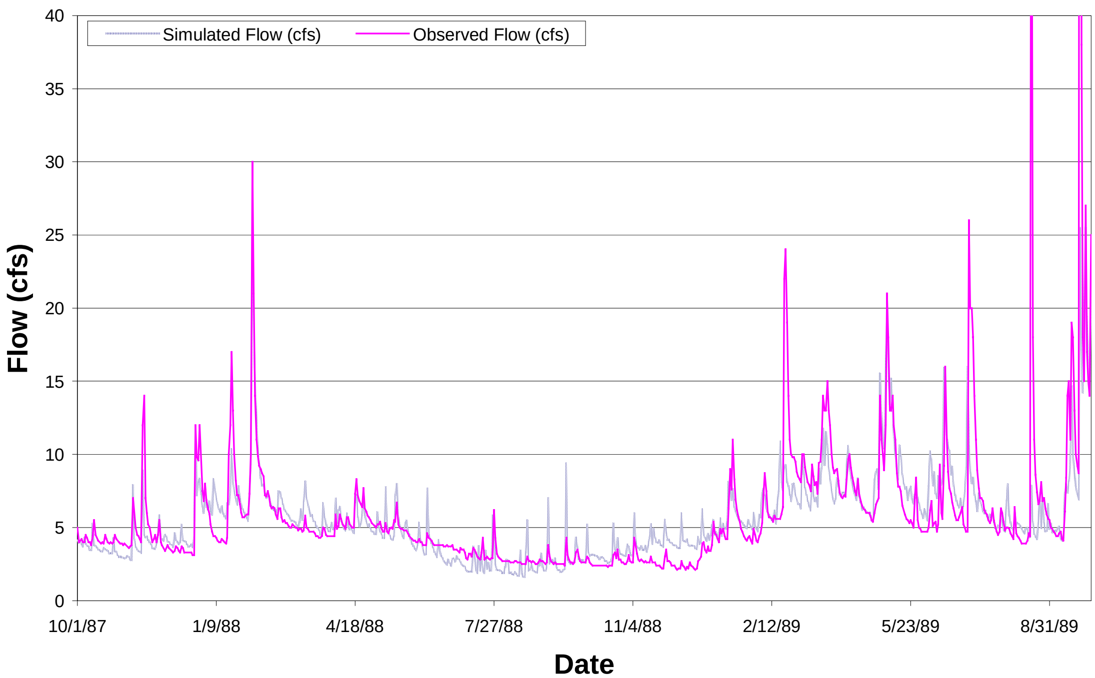
A methodical approach was followed to parameterize the model and to analyze different components of hydrologic budgets to obtain a fully calibrated model. Initial calibration efforts using of HSPEXP, an expert system for hydrologic calibration of HSPF, allowed us to determine discrepancies in input data and to select appropriate weather data. For example, the total annual evaporation at the Wytheville and Bristol Weather Stations (source: BASINS version 2, EPA) were four times as high as the NOAA recommended values. Since the daily pattern of evaporation was reasonable, the evaporation data at Wytheville and Bristol were scaled down prior to computing an average time series for the model input.

As discussed in Section 3.3.2, a time series of precipitation data was calculated using weather data from Wytheville and Bristol. Also, other meteorological input time series were computed based on the average of hourly data from the Wytheville and Bristol stations (approximate 80 miles apart) and used in model runs. It is expected that the averaging of hourly rainfall data from the two weather stations would reduce the intensity of rainfall and the resulting peak runoff, but would increase the frequency of storm events. At any given time during a storm event, the rainfall intensity and the storm hyetographs will be different at these two stations. Even if the hyetographs at Wytheville and Bristol are the same, there may be a time lag due to the travel time of the storm front from one station to another. Therefore, the arithmetic mean method of calculating hourly time series would result in a flattened hyetograph, instead of a shifted (in time) hyetograph. Occasionally, when there is a storm at one station but not at the other station, the arithmetic mean or any spatial averaging method will result in some rainfall in the calculated time series. Therefore, the frequency and sometimes the duration of the storms will increase due to the spatial averaging. However, the impact on daily bacterial load will be minimum due to the fact that the reduced flattened peak runoff will be offset by increased frequency and duration of rainfall events. Overall, spatial averaging of hourly data provides a better-input time series for hydrologic and water quality calibration and application of the model at a larger time step (e.g., daily average flow for hydrologic calibration). Model results from the hydrologic calibration run and the observed flow data are shown in Figure 4-3. The model successfully simulated the flows for most of the 2-year period. A few large storms in 1989 could not be simulated accurately due to lack of local precipitation data. Additional details on the analysis of these storms and their impacts is presented below:

- The computed precipitation input based on the average of Wytheville and Bristol data did not accurately reflect the total precipitation during large local storm events. For example, on September 22, 1989 daily precipitation recorded at Wytheville and Trout Dale were 2.2 inches and 2.3 inches, respectively. Both the stations are approximately 14 miles away from the watershed. The Wytheville station is located to the northeast and the Trout Dale station is located to the south of the watershed. The center of the storm was possibly at Groseclose and the total precipitation was much higher than the computed precipitation of 1.48 inches used for the model input. Therefore, it was the lack of local precipitation data, not the model parameters, which caused lower simulated flows.

- HSPF simulates bacteria load in runoff based on the intensity of the rainfall. The water quality calibration of the model provided that a 0.6 inch/hour rainfall would remove 90 percent of the bacteria. A rainfall intensity higher than 0.6 inches/hour will cause a smaller increase in bacteria load compared to less intense rainfall. Therefore, for large storms, the simulated flows that are less than the actual flows will not result in a prediction of significantly reduced bacteria loads.

FIGURE 4-3
Hydrologic Calibration of the Model at Groseclose



Therefore, the hydrological calibrated model was applied to Cedar Creek, Hall/Byers Creek, and Hutton Creek watersheds for validation. Results of the validation runs (daily average flow, cubic feet per second) are shown in Figures 4-4, 4-5, and 4-6. The model results accurately matched observed flows for both high and low flow conditions. It is important to note that in Figures 4-4, 4-5, and 4-6, observed flows are instantaneous measurements and simulated flows are daily average flows.

Time periods for model calibration and validation were selected based on the availability of monitoring data. Figures 4-7 shows how the data sets were divided for model calibration and validation.

FIGURE 4-4
Validation of the Hydrologic Model at Cedar Creek

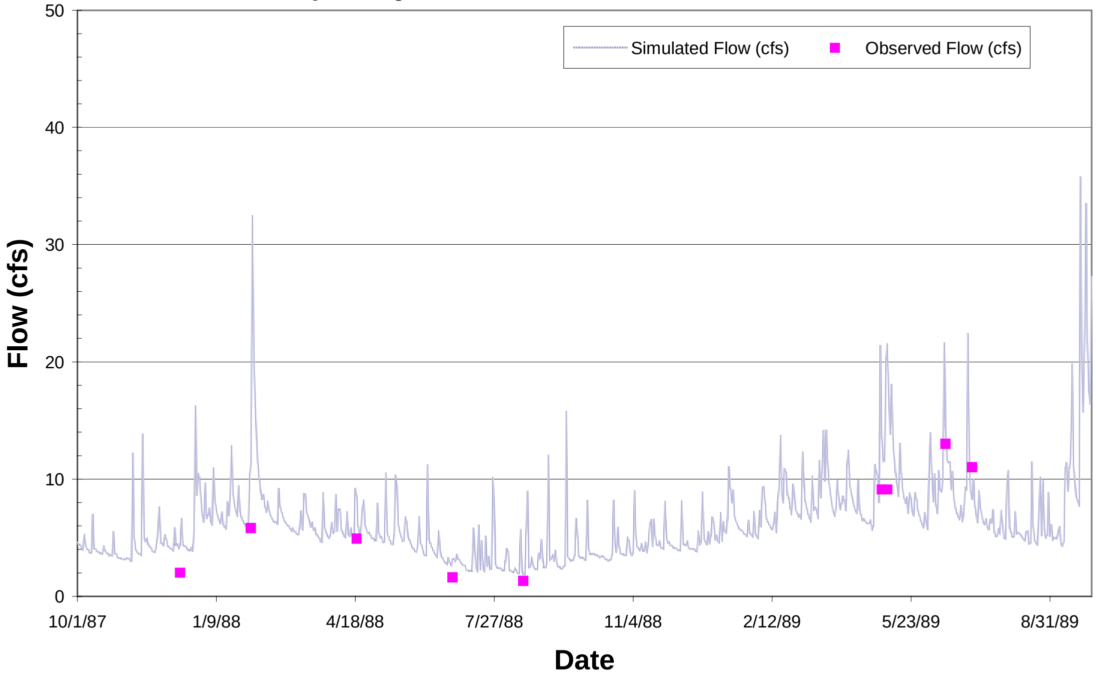


FIGURE 4-5
Validation of the Hydrologic Model at Hall/Byers Creek

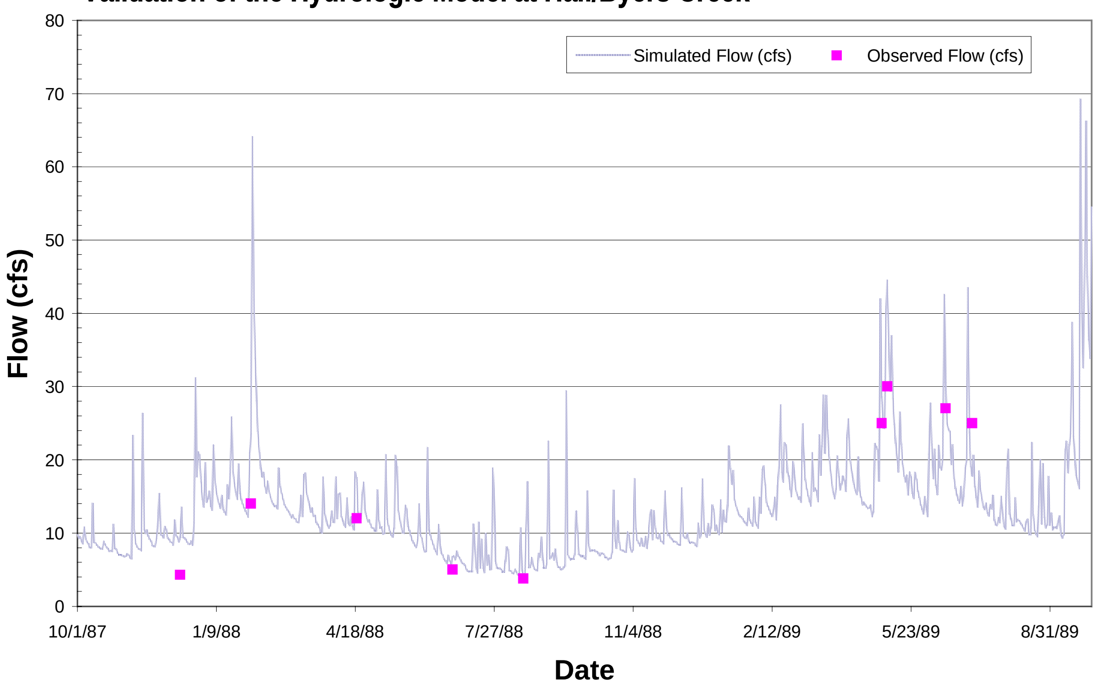


FIGURE 4-6
Validation of the Hydrologic Model at Hutton Creek

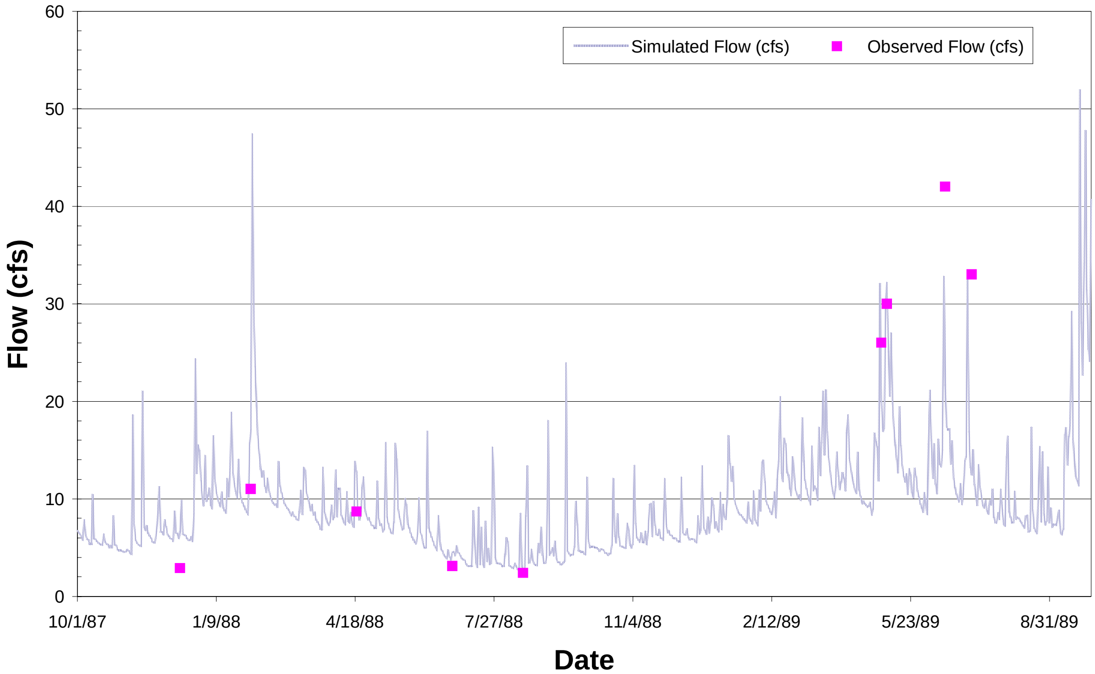
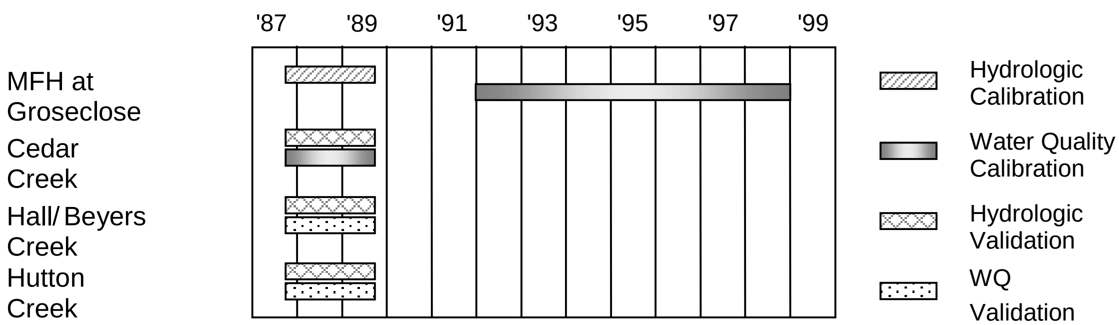


FIGURE 4-7
Data Sets Used for Model Calibration and Validation



Error statistics of the final hydrologic calibration run at Groseclose using 1987-1988 data are listed in Table 4-10.

TABLE 4-10
Error Statistics of Final Hydrologic Calibration Run at Groseclose Using 1987-88 Data
Middle Fork Holston River TMDL

Description	Simulated	Observed
Total annual runoff, in inches	8.2	8.5
Total of highest 10% flows, in inches	1.7	1.7
Total of lowest 50% flows, in inches	2.6	3.1
	Simulated	Potential
Evapotranspiration, in inches	21.7	29.3
	Simulated	Observed
Total storm volume, in inches	3.2	3.4
Average of storm peaks, in cfs	9.5	9.4
Baseflow recession rate	1.0	1.0
Total simulated storm interflow, in inches	0.8	
Total simulated storm surface runoff, in inches	0.6	
	Simulated	Observed
Summer flow volume, in inches	1.2	1.3
Winter flow volume, in inches	3.1	2.9
Summer storm volume, in inches	0.0	0.0
	Current	Criteria
Error in total volume	-3.8	10.0
Error in low flow recession	0.0	0.0
Error in 50% lowest flows	-13.9	15.0
Error in 10% highest flws	-4.3	10.0
Error in storm volumes	-7.0	10.0

4.7.2 Water Quality Calibration and Validation

The hydrological calibrated and validated model was setup at the Groseclose watershed to perform a preliminary water quality calibration. The final calibration of the model was performed at the Cedar Creek watershed with limited low-flow and high-flow fecal coliform measurements. The model was finally validated using the water quality at Hall/Byers Creek and Hutton Creek watersheds.

Although GIS data were available for the Groseclose watershed, it was beyond the scope to obtain the details of farm animals and wildlife in the area. It was assumed that the computed land use, specific build-up rates for Cedar Creek would be close to the values expected at the Groseclose watershed. Due to the proximity of the Groseclose watershed to the study area and the similarity of environmental conditions and sources, it was justifiable to use the fecal coliform build-up rate from one of the three study watersheds. Additionally, the primary objective of performing a preliminary calibration of the model was to make sure that the simulated values were within a reasonable range for an extended period of time. There were 32 observations of fecal coliform concentrations at Groseclose between 1992 and 1998. Figure 4-8 shows simulated and observed fecal coliform concentrations in the Middle Fork Holston River at Groseclose.

Figure 4-9 shows the results of final water quality calibration of the model at Cedar Creek. Results of the validation runs at Hall/Byers and Hutton Creeks are shown in Figure 4-10 and Figure 4-11. The model simulated the fecal coliform concentrations under dry-weather (1987-88) and wet-weather (1989) conditions very well, especially in the Cedar and Hall/Byers Creek watersheds. The observed dry-weather fecal coliform concentrations in Hutton Creek were higher than the simulated values, which can be attributed to the fact that the observations were instantaneous where as the simulated values were daily average concentrations. In addition, the discrepancies also may be due to cattle access to the stream that was in existence in 1989.

FIGURE 4-8
Preliminary Water Quality Calibration at Middle Fork Holston River Near Groseclose

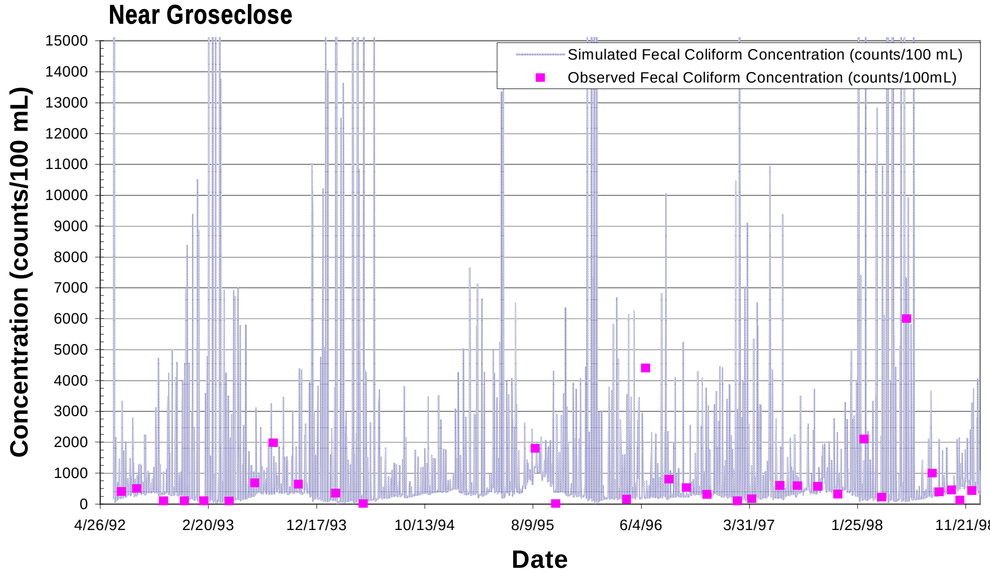


Figure 4-9
Water Quality Calibration at the Cedar Creek

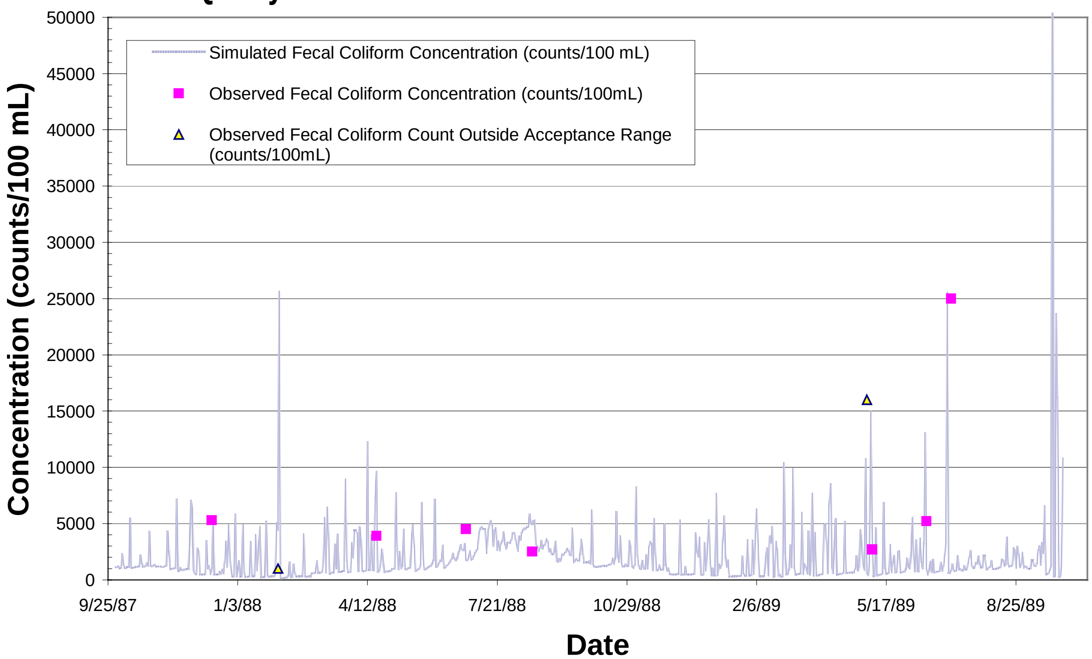


FIGURE 4-10
Validation of the Water Quality Model at Hall/Byers Creek

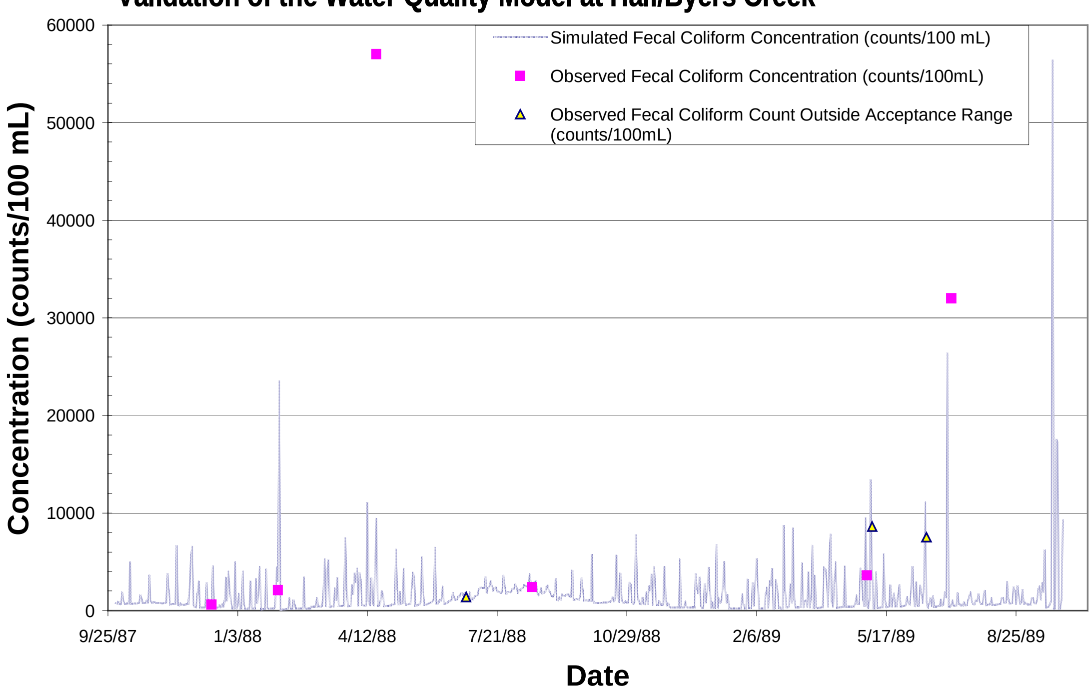
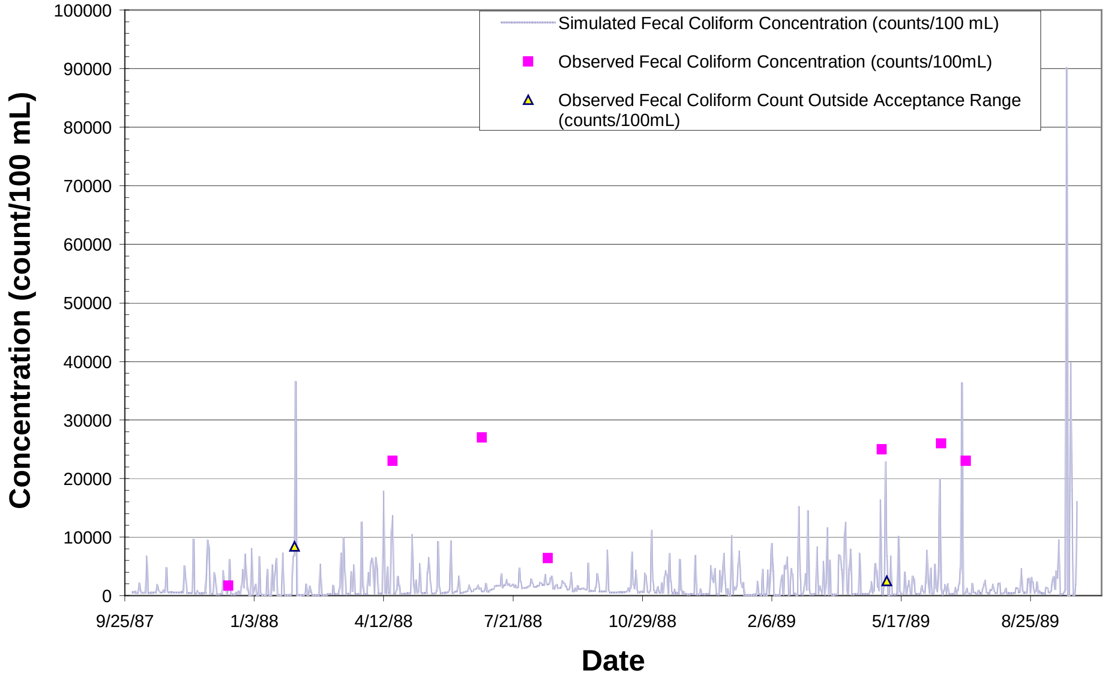


FIGURE 4-11
Validation of the Water Quality Model at Hutton Creek



4.8 Resulting Loads

The total loads from different land uses and sources as estimated by the models are illustrated in Figures 4-12 through 4-16.

- Figure 4-12 shows the calculated accumulation rates
- Figure 4-13 shows distribution of land use in the Cedar Creek watershed
- Figure 4-14 shows the simulated loads per acre of each land use type
- Figure 4-15 shows the average flow by month
- Figure 4-16 shows the distribution of total loads by land uses for each month

4.8.1 Representative Hydrologic Year

A representative hydrologic time period was selected for developing the watershed loads and for developing the allocation scenario. Average precipitation in the study area was found to be 38 inches. This value is lower than the average rainfall predicted by the Parameter-elevation Regressions on Independent Slopes Model (PRISM) (Section 3.3.2). PRISM is an expert system that uses point data and a digital elevation model (DEM) to generate gridded estimates of climate parameters (Daly et al., 1994). According to PRISM, the annual precipitation in the study area is 43 inches. PRISM data was used only to select appropriate meteorological stations for modeling. Once the stations were selected, actual hourly precipitation data from the selected stations was used for modeling. The precipitation time series developed using the arithmetic mean method (Section 3.3.2) showed an average 38 inches of annual rainfall based on 1987-1998 data. According to the precipitation data, total yearly rainfall in the 1990, 1993, and 1998 water years (October 1st to September 30th) were 39.19, 40.35, and 38.56 inches, respectively.

The distribution of monthly rainfall data (Figure 4-17) shows that the 1993 water year matched average monthly rainfall better than 1990 and 1998. A wet year would cause a higher proportion of total load contributed from nonpoint sources and, thus, biased assessment. Therefore, the 1993 water year was considered a representative year for further analysis and development of the allocation scenario.

FIGURE 4-12
Cedar Creek: Fecal Coliform Build-up Rates for Existing Conditions

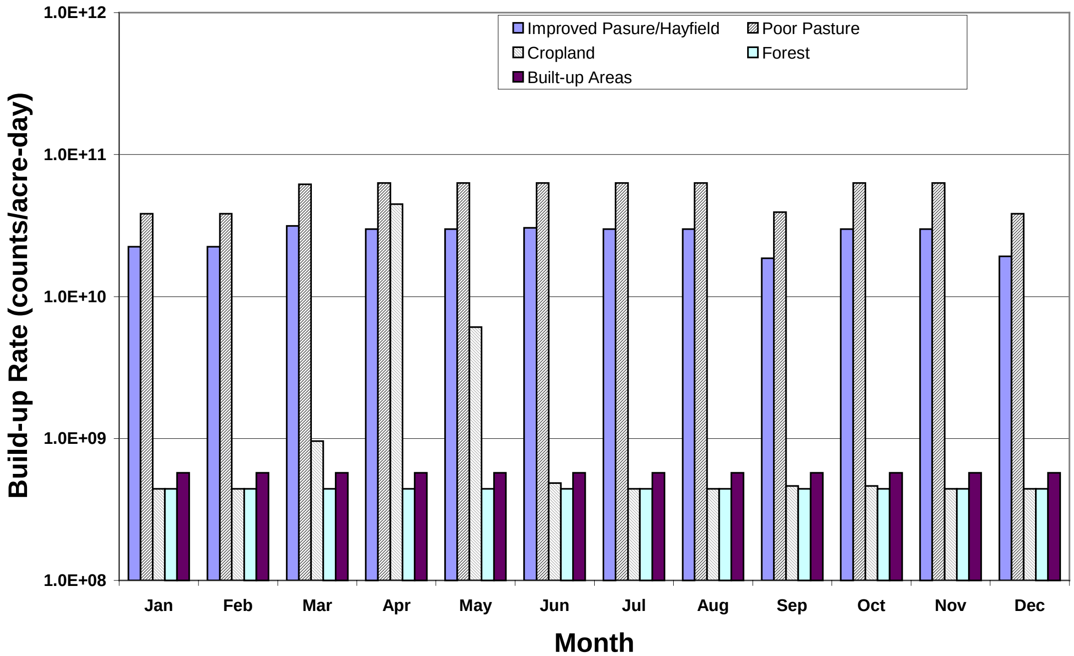


FIGURE 4-13
Cedar Creek Distribution of Land Use Areas
(Total Area = 4,629 ac)

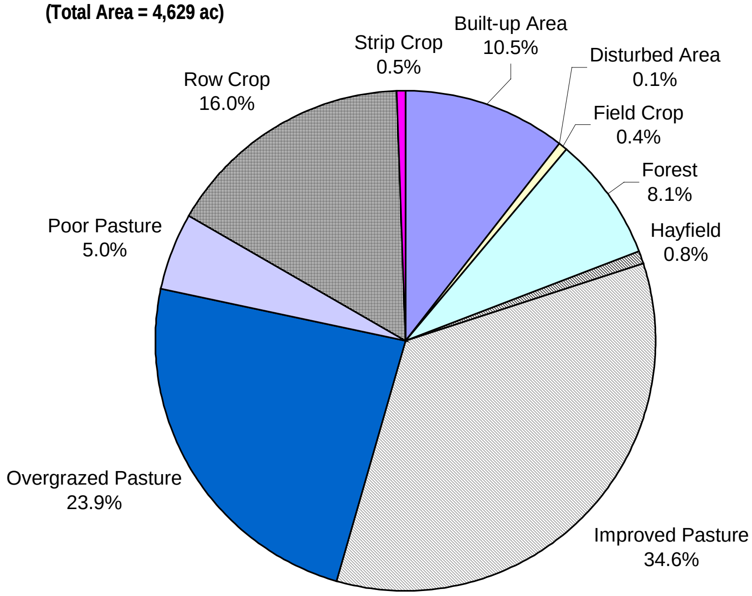


FIGURE 4-14
Cedar Creek Average Monthly Fecal Coliform Loading Rate by Land Use

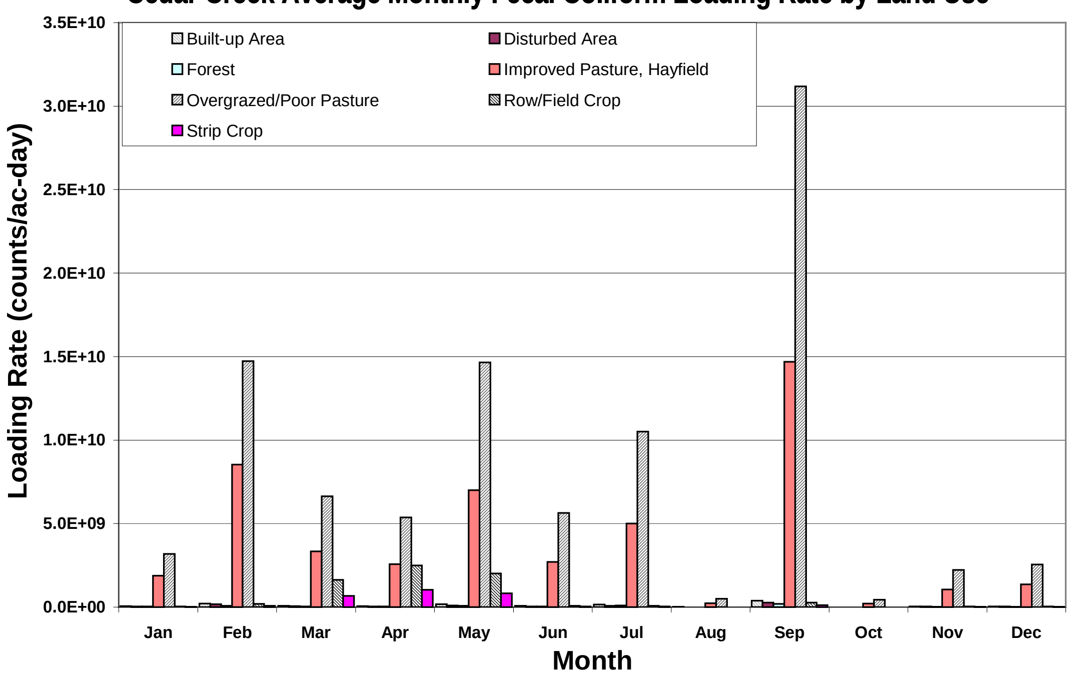


FIGURE 4-15
Cedar Creek Average Flow by Month (Most Downstream Reach)

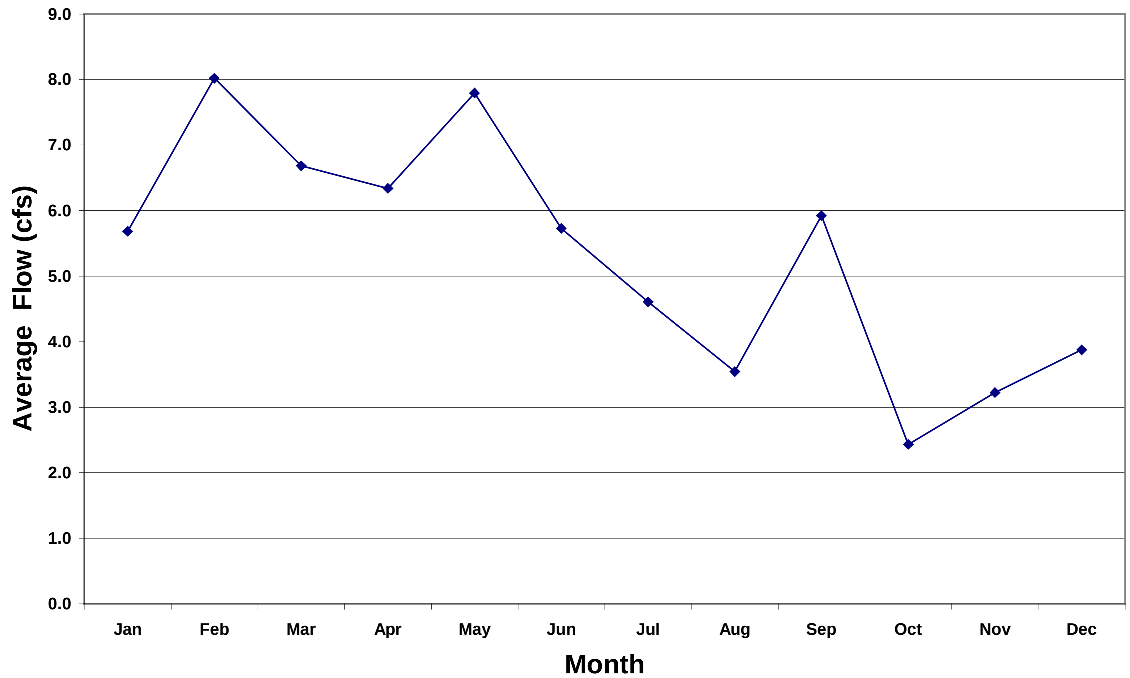


FIGURE 4-16
Cedar Creek Average Fecal Coliform Loads By Land Use

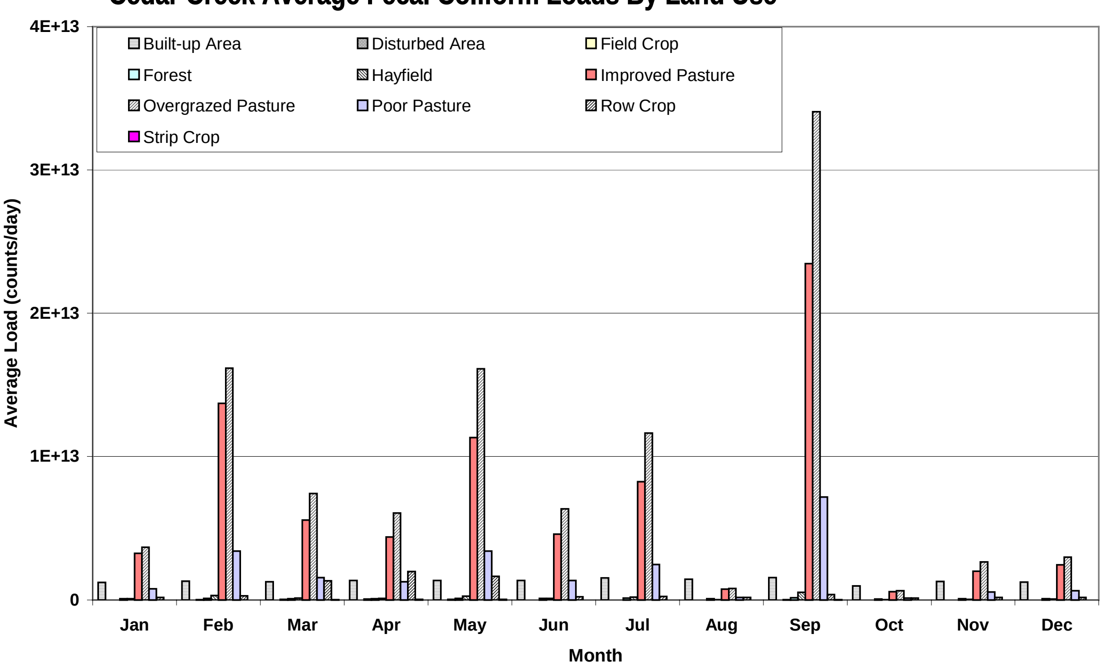
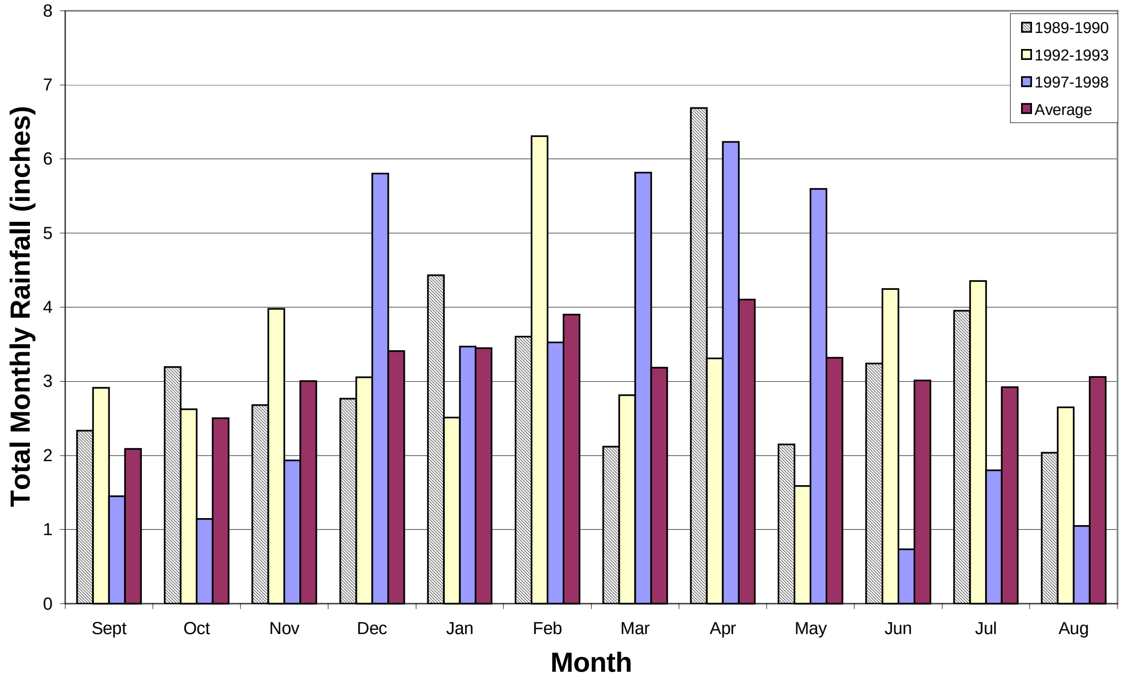


FIGURE 4-17
Distribution of Monthly Rainfall



4.8.2 Existing Condition

The model was setup for Cedar Creek, Hall/Byers Creek, and Hutton Creek to estimate total loads and their distributions by sources under existing (1999) conditions. Except for meteorological data, all other data (e.g., land use, septic failures) represented the prevailing conditions in the watersheds in 1999. The effect of different BMPs in reducing the loads was incorporated in the model. The 1993 precipitation data was used to determine loads under representative hydrologic conditions, as described above.

Figures 4-18, 4-19, and 4-20 show the 30-day geometric mean of fecal coliform concentrations in Cedar Creek, Hall/Byers Creeks, and Hutton Creek, respectively. The water quality standard of 200 counts/100 mL for 30-day geometric mean is almost always violated.

FIGURE 4-18
Cedar Creek, 30-day Geometric Mean of Fecal Coliform Concentrations

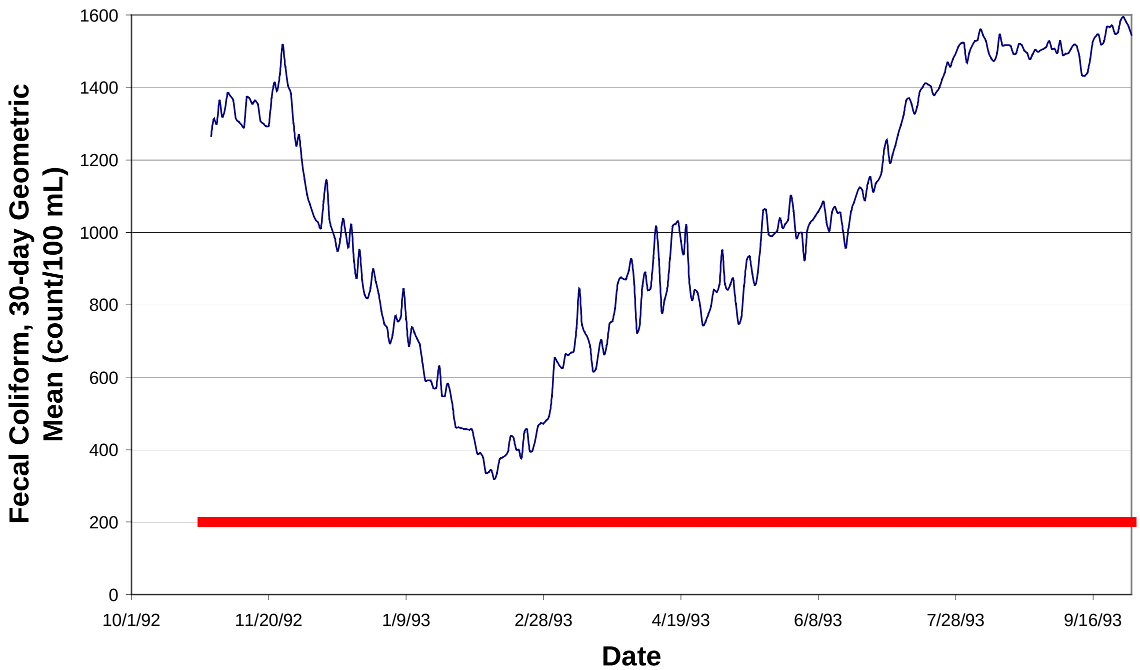
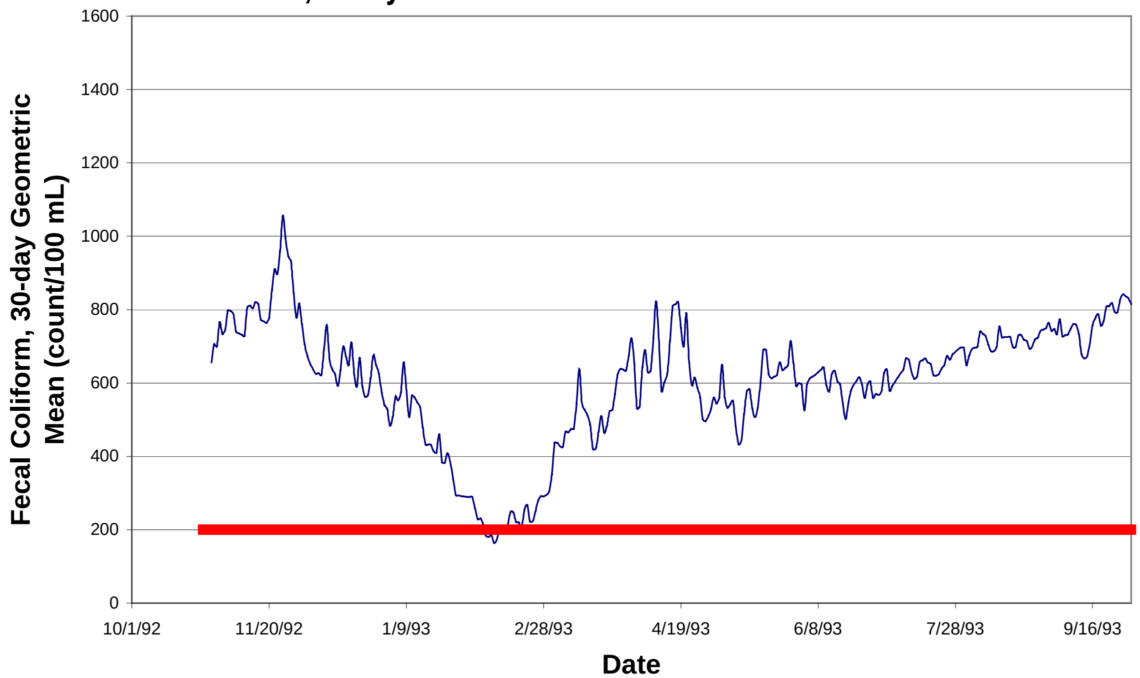


FIGURE 4-19
Hall/Byers Creek, 30-day Geometric Mean of Fecal Coliform Concentrations

FIGURE 4-20
Hutton Creek, 30-day Geometric Mean of Fecal Coliform Concentrations



The distribution of loads by sources is shown in Figures 4-21, 4-22, and 4-23 for Cedar Creek, Hall/Byers Creeks, and Hutton Creek, respectively.

Figure 4-21
Cedar Creek: Annual Fecal Coliform Load - Existing Condition

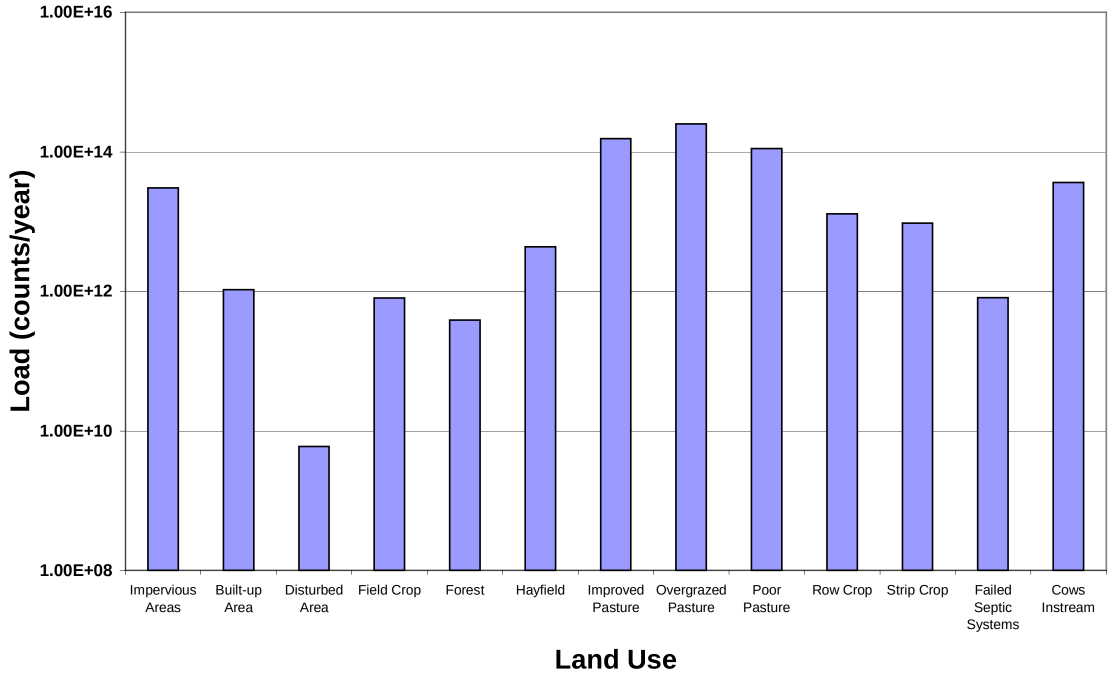


FIGURE 4-22
Hall/Byers Creeks: Annual Fecal Coliform Load - Existing Condition

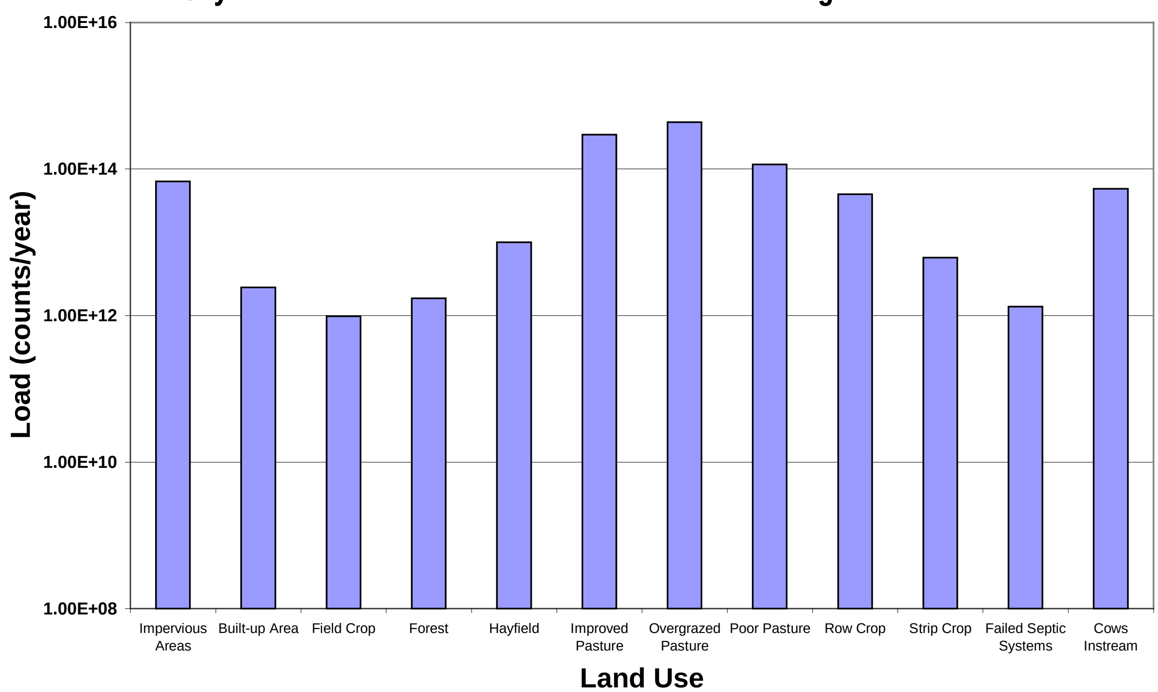
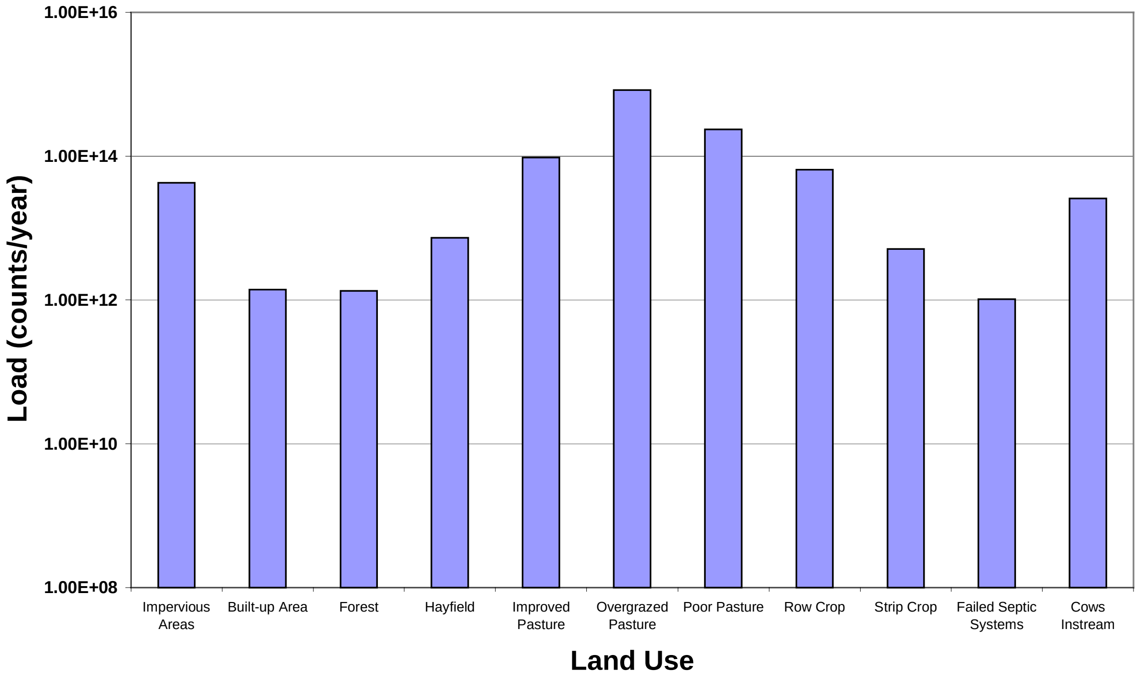


FIGURE 4-23
Hutton Creek: Annual Fecal Coliform Load - Existing Condition



4.8.3 BMP Impacts on Fecal Coliform Loads

The model for existing conditions were run with and without BMPs. Model results of fecal coliform loads from sources with BMPs reflect a significant reduction compared to the loads from the pre-BMP condition. Figure 4-24 shows comparisons of fecal coliform loads from each acre of cropland and pasture land for pre-BMP and post-BMP conditions. BMPs considered in these cases include conversion of row crop and field crop to strip crop and poor, and conversions of overgrazed pasture to improved pasture.

Figure 4-25 shows the overall reduction of annual loads from cropland in the Cedar Creek, Hall/Byers Creek, and Hutton Creek watersheds due to implementation of BMPs. A comparison of pre- and post-BMP loads and the percent reduction in loading to the streams as a result of BMPs are presented in Table 4.11. Given the significant number and coverage of BMPs that have been implemented, the allocation scenarios are based on the model runs with BMPs.

TABLE 4.11
Fecal Coliform Loads (Counts) by Watershed for Pre- and Post-BMP Conditions

Watershed	Annual Fecal Coliform Load (counts)		Percent Reduction
	Pre-BMP	Post-BMP	
Cedar Creek Watershed	5.89E+14	4.97E+14	15.6%
Hall/Byers Creek Watershed	9.90E+14	8.41E+14	15.1%
Hutton Creek Watershed	1.29E+15	1.13E+15	12.2%

FIGURE 4-24
Comparison of Fecal Coliform Loads from Land Uses with and without BMPs - Cedar Creek Watershed

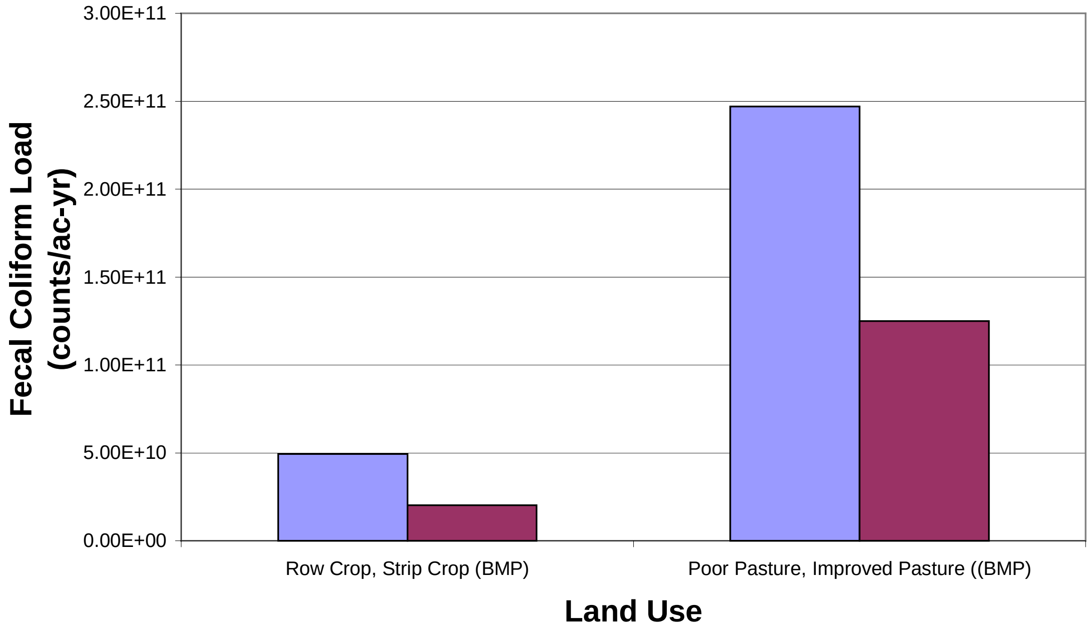
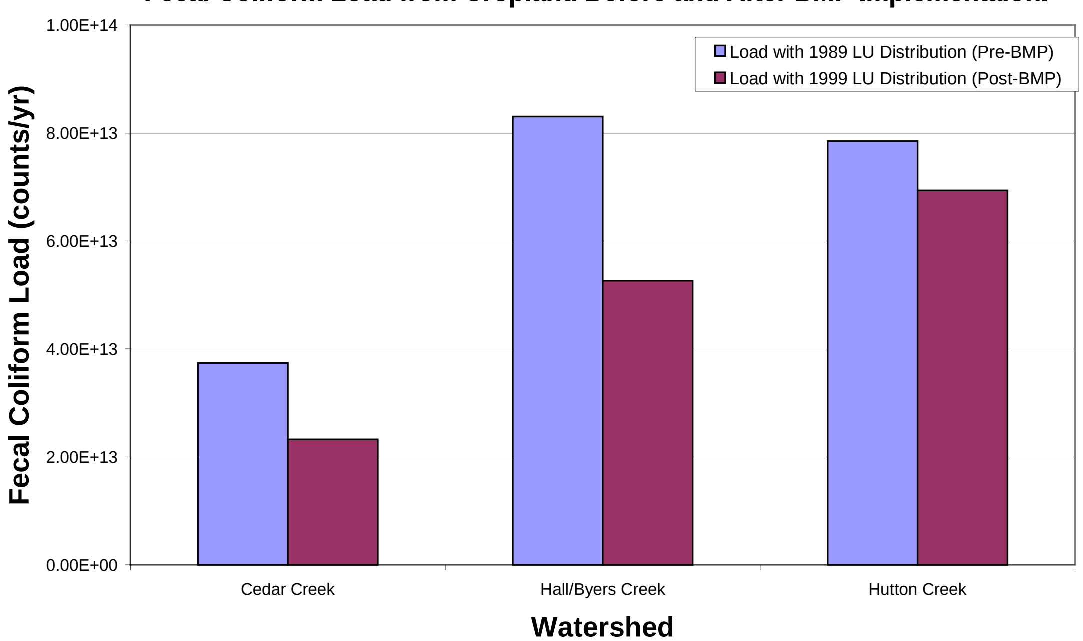


FIGURE 4-25
Fecal Coliform Load from Cropland Before and After BMP Implementaion.



4.8.4 Seasonal Variability

The model explicitly considered seasonal variation in fecal coliform loads through hourly variation of meteorological data, monthly variation of fecal coliform accumulation rates and monthly varying loads from cows in streams.

The hydrologic and water quality calibration and validation of the model demonstrated the credibility of the model in the different seasons of the year (low and high flow periods) and on a continuous basis.

5.0 TMDL Allocation Scenarios

5.1 Approach and Methodology

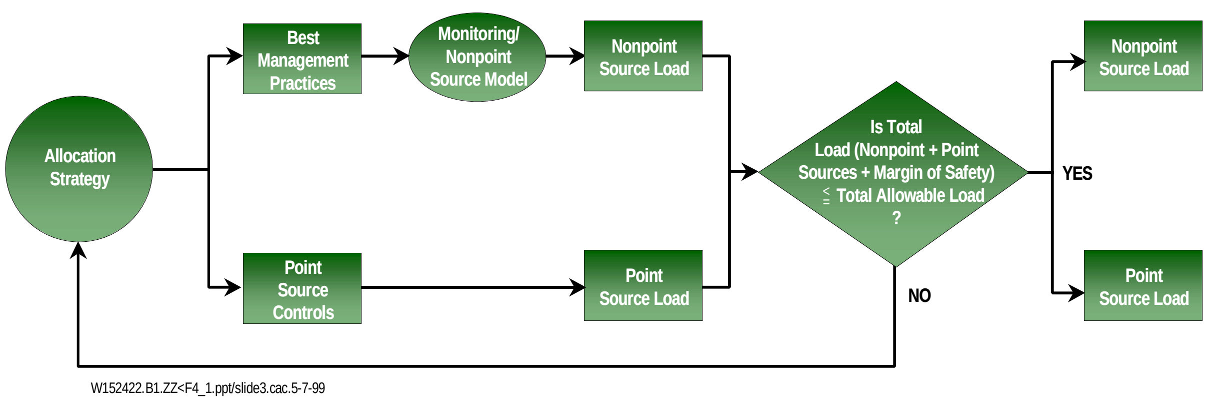
Total maximum daily loads (TMDLs) are the sum of the individual waste load allocations (WLAs) for point sources, load allocations (LAs) for both nonpoint sources and natural background, and a margin of safety (MOS). This definition is denoted by the following equation:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

For bacteria, TMDLs are expressed in terms of organism counts (or resulting concentrations), in accordance with 40 CFR 130.2(I).

Figure 5-1 shows the iterative process involved in developing an allocation scenario. Each allocation scenario was tested using the calibrated model to evaluate the potential effectiveness of the proposed alternative. Seasonal variability of fecal coliform concentrations and flow was considered explicitly in the model through continuous simulation and time varying input variables, as discussed in Section 4.

FIGURE 5-1
Allocation Scenario Process



5.2 Selection of TMDL Scenario

The TMDL development requires that the level of reduction from each pollutant source in each of the four watersheds be determined in order to meet the applicable water quality standards. The allocation scenario is based on a representative hydrologic year as discussed in Section 4. The allocation scenario also accounts for future growth, incorporates a margin of safety, and provides levels of reduction in pollution form point and nonpoint sources as described below.

5.2.1 Wasteload Allocation

Currently there are two point source dischargers – Dillows Shop and Car Wash and Meadowview Elementary School in the Cedar Creek watershed and one point source discharger – the Emory-Meadowview WWTP in the Hall/Byers Creek watershed. There is no point source discharger in the Hutton Creek watershed.

The wasteload allocation for these dischargers was calculated based on the permitted flows and fecal coliform concentration of 200 counts/100 mL. Table 5-1 lists the wasteload allocations for the dischargers.

TABLE 5-1
Wasteload Allocation (counts/day) for Point Sources
Middle Fork Holston River TMDLs

Point Source Name	Existing Load	Allocated Load	Percent Reduction
Dillows Shop and Car Wash	2.73E+07	2.73E+07	0%
Meadowview Elementary School	1.51E+07	1.51E+07	0%
Emory-Meadowview WWTP	2.15E+08	2.15E+08	0%

5.2.2 Load Allocations

Load allocations indicate the reduction in nonpoint source contribution of fecal coliform needed to meet water quality standards.

Tables 5-2, 5-3, and 5-4 provide the details of nonpoint source load reductions needed in each land use and watershed activity to meet water quality standards in Cedar Creek, Hall/Byers Creek, and Hutton Creek, respectively.

The water quality standard is expressed as a concentration of fecal coliform (200 counts/100 mL). The total allowable load is a function of the daily concentrations and the corresponding flows. Because of the complexity of the relationships among different variables that define concentrations and flow, an iterative approach is necessary to determine the final allocation scenario that meets the water quality standard. Numerous trials were made using different combinations of load reductions until the selected scenario was identified.

Table 5-5 presents a comparison of a trial scenario to the final scenario for the Cedar Creek watershed. The trial scenario requires a significant reduction of direct loads from cattle in the stream and failed septic systems as well as load reductions from row crop and overgrazed pasture. Note that these reductions are above and beyond the implemented best management practices (BMPs) described in previous sections. Compared to the final scenario, the trial scenario would require significant improvement in land uses and additional BMPs. However, the water quality standard is not met for the trial scenario. Additional reductions in loads from cattle in the streams and from failed septic systems were necessary to meet the water quality standard. Therefore, the final scenario was the best load allocation for the Cedar Creek watershed. Similarly, the load allocations for Hall/Byers Creeks and Hutton Creek watersheds required significant reduction of loads from cattle in the stream and failed septic systems; and an additional 10 percent reduction of land applied waste on improved pasture and hayfield in the Hutton Creek watershed to meet the water quality standard.

A detailed analysis of loads from different sources, different stream flow conditions, and wet and dry weather concentrations, showed that high concentrations of fecal coliform between storm events (dry weather conditions) were the primary cause of violations of the 30-day geometric mean fecal coliform standard. Exceedence of 200 counts / 100 mL of fecal coliform concentrations (based on model results and observed data) that occur on a regular basis prevents any scenario from meeting the 30-day geometric mean standard unless the loads are significantly reduced during dry weather conditions, as shown in the final scenario.

TABLE 5-2
Cedar Creek Existing and Allocated Fecal Coliform Loads
Middle Fork Holston River TMDLs

Source	Existing Loads (counts/year)	Allocated Loads (counts/year)	Percent Reduction
Impervious Areas	3.02E+13	3.02E+13	0
Built-up Area	1.06E+12	1.06E+12	0
Disturbed Area	6.02E+09	6.02E+09	0
Field Crop	8.01E+11	8.01E+11	0
Forest	3.9E+11	3.90E+11	0
Hayfield	4.38E+12	4.38E+12	0
Improved Pasture	1.55E+14	1.55E+14	0
Overgrazed Pasture	2.51E+14	2.51E+14	0
Poor Pasture	1.11E+14	1.11E+14	0
Row Crop	1.29E+13	1.29E+13	0
Strip Crop	9.58E+12	9.58E+12	0
Failed Septic Systems	8.1E+11	5.67E+09	99.3
Cows Instream	3.64E+13	2.55E+11	99.3

TABLE 5-3
Hall/Byers Creeks Existing and Allocated Fecal Coliform Loads
Middle Fork Holston River TMDLs

Source	Existing Loads (counts/year)	Allocated Loads (counts/year)	Percent Reduction
Impervious Areas	6.75E+13	6.75E+13	0
Built-up Area	2.43E+12	2.43E+12	0
Field Crop	9.80E+11	9.80E+11	0
Forest	1.73E+12	1.73E+12	0

TABLE 5-3
Hall/Byers Creeks Existing and Allocated Fecal Coliform Loads
Middle Fork Holston River TMDLs

Source	Existing Loads (counts/year)	Allocated Loads (counts/year)	Percent Reduction
Hayfield	1.00E+13	1.00E+13	0
Improved Pasture	2.94E+14	2.94E+14	0
Overgrazed Pasture	4.37E+14	4.37E+14	0
Poor Pasture	1.16E+14	1.16E+14	0
Row Crop	4.55E+13	4.55E+13	0
Strip Crop	6.20E+12	6.20E+12	0
Failed Septic Systems	1.32E+12	2.11E+10	98.4
Cows Instream	5.38E+13	8.61E+11	98.4

TABLE 5-4
Hutton Creek Existing and Allocated Fecal Coliform Loads
Middle Fork Holston River TMDLs

Source	Existing Loads (counts/year)	Allocated Loads (counts/year)	Percent Reduction
Impervious Areas	4.26E+13	4.26E+13	0
Built-up Area	1.4E+12	1.4E+12	0
Forest	1.33E+12	1.33E+12	0
Hayfield	7.33E+12	6.60E+12	10
Improved Pasture	9.61E+13	8.65E+13	10
Overgrazed Pasture	8.29E+14	8.29E+14	0
Poor Pasture	2.35E+14	2.35E+14	0
Row Crop	6.45E+13	6.45E+13	0
Strip Crop	5.12E+12	5.12E+12	0
Failed Septic Systems	1.03E+12	0.00E+00	100.0
Cows Instream	2.59E+13	0.00E+00	100.0

TABLE 5-5
Percent Reduction of Loads from Different Sources for a Trial Scenario and the Final Scenario (Cedar Creek)
Middle Fork Holston River TMDL

Source	Trial Scenario [(a)]	Final Scenario
Cattle in Stream	95	99.3
Failed Septic Systems	96	99.3
Row Crop to Strip Crop	50	0
Overgrazed to Improved Pasture	60	0

[a] The trial scenario does not meet the water quality standard for fecal coliform

It is anticipated that in the implementation of stream fencing to eliminate the direct deposition of fecal matter from cattle in the stream, that the 10 percent reduction in the fecal loading from improved pasture and hayfield will be met without requiring additional management measures. Stream fencing will result in substantial improvements to riparian areas, which will reduce the amount of overland runoff entering the stream. In addition to stream fencing, the installation of alternative watering systems will improve pasture management and the quality of forages. This will further reduce the fecal loading to Hutton Creek from pasture.

5.3 Future Growth

Future growth may have an impact on TMDL allocation scenarios in two ways:

- Modified point source loads
- Modified nonpoint source loads

A change in *point source loads* may occur due to an increase (or decrease when there is a declining population) in population densities in existing clusters or development of new clusters. In an unsewered area an increase in population will increase the load from failed septic systems, where as in a sewered area an increase in population may or may not have a direct impact on the impaired stream segments depending on the discharge location of the wastewater treatment plant. The discharge from the Emory-Meadowview WWTP to Hall Creek will increase as a result of the growth in the sewered population. Therefore, modeling for future conditions explicitly considered the location and size of future population growth, future coverage of sewered areas, and potential for a new or expanded wastewater treatment facility. However, the wasteload allocation for all point sources were calculated based on the permitted flows and fecal coliform concentration of 200 counts / 100 mL.

Future growth will also affect *nonpoint source pollution* by changing land use coverage in the watersheds. For example, forested areas converted to agricultural or residential land will have an impact on water quality in the impaired segments.

Future growth in the watersheds was estimated based on historic population growth in the area obtained from the census data. The growth projections were made to the year 2010.

Each type of source was assessed to determine the potential in increase fecal coliform load. Loads from failed septic system and pet populations were increased based on estimated population growth.

The number of farm animals in each watershed was assumed to remain unchanged. According to the Department of Conservation and Recreation (DCR) Nutrient Management Specialist, Dean Gall, the number of farm animals in the watershed is decreasing. Therefore, the assumption that the number of farm animals will remain unchanged provides a conservative estimate of fecal coliform loads.

An analysis change in historic land use data showed an increase in built-up areas, strip cropping, and improved pasture. Fecal coliform load from each acre of built-up area is less than the load from an acre of pasture or cropland. If the trend continues the water quality in the streams, based on fecal coliform loads, will improve. To develop a conservative estimate of the fecal coliform loads, land use in the Cedar Creek, Hall/Byers Creeks, and Hutton Creek watersheds was assumed to remain unchanged in the future.

5.4 Sensitivity Analysis and Margin of Safety

5.4.1 Model Sensitivity

The model was setup for background conditions with loads from wildlife population only. Two different model runs with fecal coliform contribution from wildlife at existing rate and at double the existing rate showed no violation of water quality standards. Therefore, some increase in wildlife population will not significantly impact the water quality in the Cedar Creek, Hall/Byers Creek, and Hutton Creek.

The model was also setup with existing BMPs and the reduction of pollutant loads due BMPs. The removal efficiency of BMPs directly impacts the load contributed from different nonpoint sources. Therefore, the model was sensitive to the removal efficiencies of BMPs and acreage served by BMPs.

A large number of agricultural BMPs have been implemented in these watersheds since the mid-1980’s as a result of nonpoint source programs led by DCR and implemented by the property owners in the watersheds with assistance from the Holston River Soil and Water Conservation District, the New River Highlands Resource Conservation and Development Area, and the Natural Resources Conservation Service (NRCS). Agricultural BMPs “cover” approximately 1,157 acres (25 percent) of the Cedar Creek watershed; 2,036 acres (20 percent) of the Byers/Hall Creek watershed; and 1,249 acres (17 percent) of the Hutton Creek watershed.

5.4.2 Margin of Safety

Section 303(d) of the Clean Water Act (CWA) requires TMDLs to include “a *margin of safety* which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.” There are two methods for incorporating the margin of safety (USEPA 1991, *Guidance for Water Quality-Based Decisions: The TMDL Process*. EPA 440/4-91-001):

- Implicitly incorporate the margin of safety using conservative model assumptions to develop allocations
- Explicitly specify a portion of the total TMDL as the margin of safety; use the remainder for allocations

The allocation scenario for the four watersheds was designed to meet the water quality standard of a geometric mean of 200 counts/100 mL with 0 percent exceedences. To provide an explicit 5 percent margin of safety, the modeled concentrations were compared to a target geometric mean (of 30 samples) of 190 counts/100 mL.

Figures 5-2, 5-3, and 5-4 show the results of the allocation scenario for Cedar Creek, Hall/Byers, and Hutton Creek watersheds. These figures demonstrate that fecal coliform concentrations for the representative hydrologic year (1993) meet the water quality standard including the margin of safety requirements.

FIGURE 5-2
Cedar Creek: Simulated Fecal Coliform Concentrations and Water Quality Standard

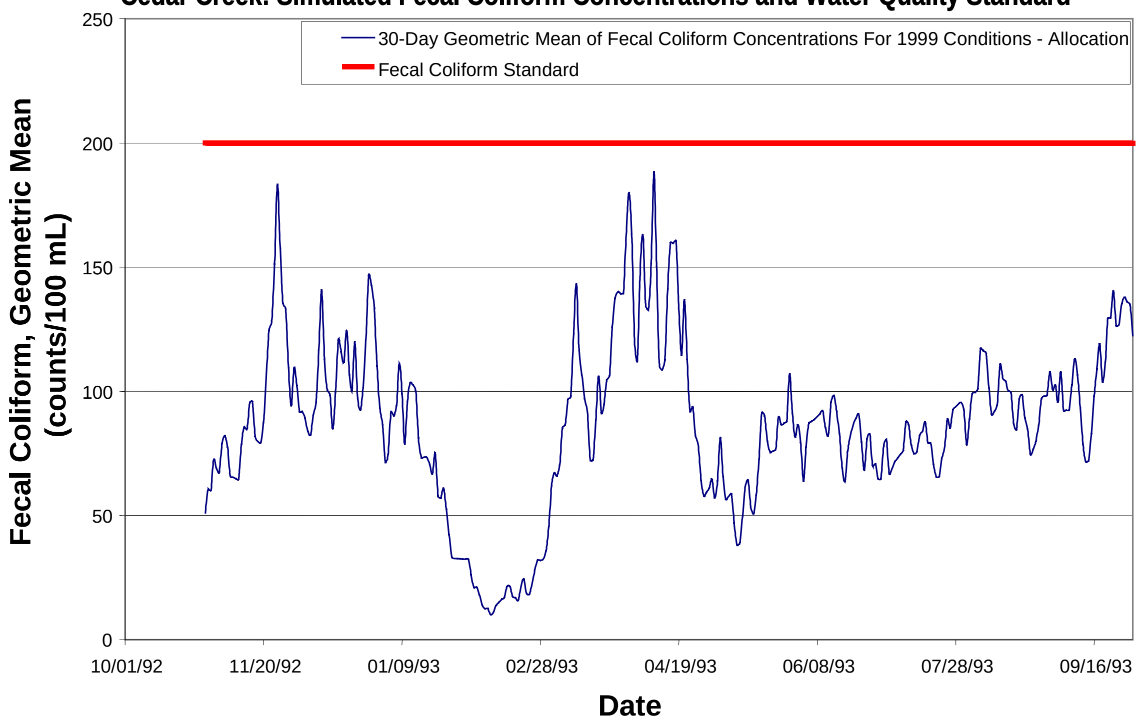


FIGURE 5-3
Hall/Byers Creeks: Simulated Fecal Coliform Concentrations and Water Quality Standard

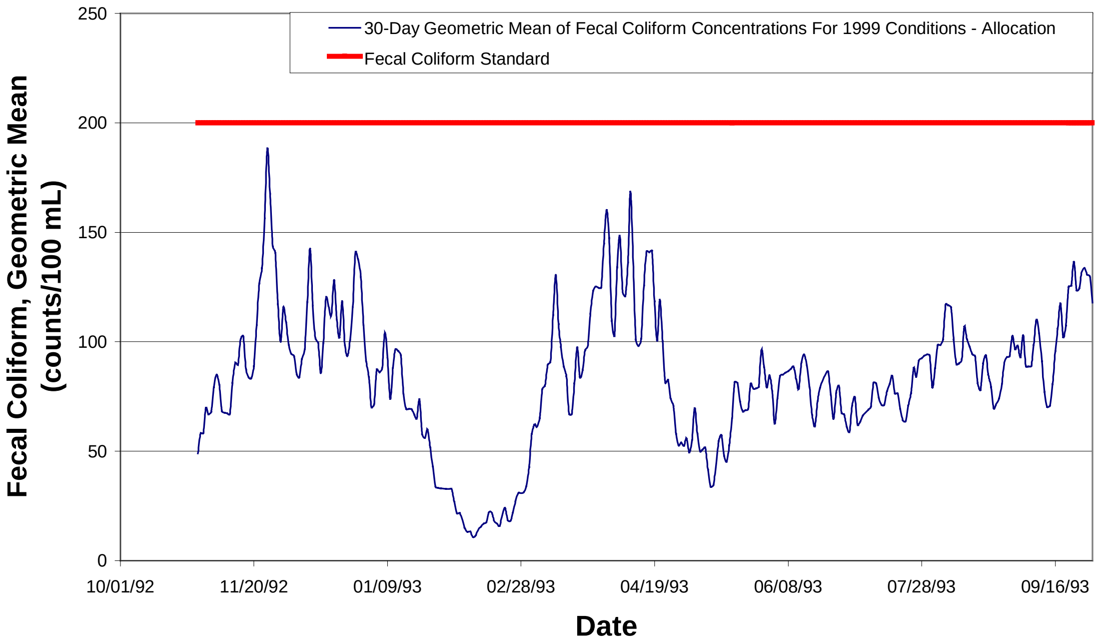
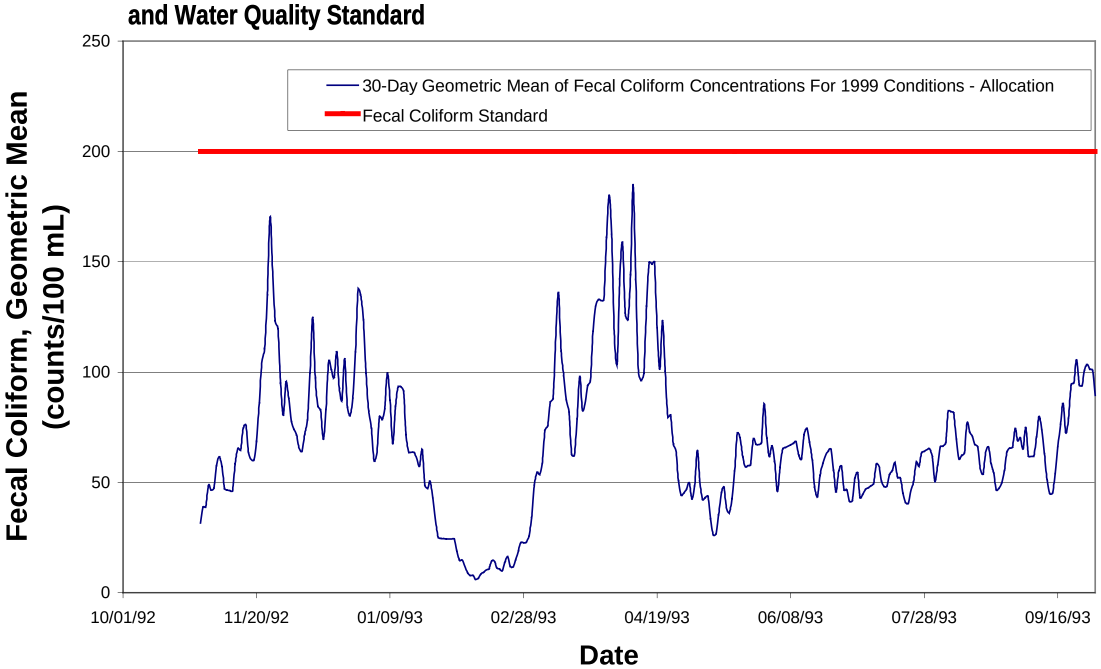


FIGURE 5-4
Hutton Creek: Simulated Fecal Coliform Concentrations and Water Quality Standard



5.5 TMDL Summary

The fecal coliform TMDL was developed to achieve full compliance with Virginia's water quality standard for fecal coliform, described in Section 1.2, and according to the methodology and loads presented in Sections 5.1 – 5.4. Specifically, the 200 fecal coliform bacteria counts per 100 mL, geometric mean standard, were used for the TMDL allocations. Table 5-6 summarizes the elements of the TMDL.

Reductions in discharges from failing septic systems and cattle contributions directly deposited in the stream (cows in the stream) will be required, as described in Section 5.2, in order to achieve compliance with water quality standards in the four creeks.

TABLE 5.6
Summary of Fecal Coliform TMDL Calculated to Average Annual Loading (counts/year)
Middle Fork Holston River TMDLs

Watershed	TMDL200 (a) (counts/year)	WLA (b) (counts/year)	LA (c) (counts/year)	MOS (d) (counts/year)
Cedar Creek	6.07E+14	1.55E+10	5.77E+14	3.04E+13
Hall/Byers Creeks	1.03E+15	7.85E+10	9.83E+14	5.17E+13
Hutton Creek	1.35E+15	0	1.28E+15	6.75E+13

a TMDL200 represents loading that corresponds compliance with the 200 count/100 mL geometric mean standard.
b Derived from Table 5-1, Waste Load Allocation for Point Sources.
c Summation of load allocations from Table 5-2, Cedar Creek; Table 5-3, Hall/Byers Creeks; Table 5-4, Hutton Creek; Existing and Allocated Fecal Coliform Loads.
d A 5% MOS is used to target load reductions to meet a monthly geometric mean of 190 counts/100 mL (i.e., 5% of the 200 counts/100 mL geometric mean standard). In order to express this MOS explicitly for the purpose of this summary, the loading in this table is calculated based on the equation: TMDL200 = WLA + LA + (0.05 TMDL200).
This equation is used for illustration purposes only since the standard is based on concentrations.

6.0 Implementation Plan

6.1 Follow-up Monitoring Plan

Currently, there are no ambient monitoring stations located in Hutton, Cedar, and Hall / Byers Creeks; therefore, DEQ will establish ambient stations that will be located near the mouth of each creek. DEQ and DCR will use water quality data from these monitoring stations for evaluating reductions in fecal coliform bacteria counts and to determine the effectiveness of the TMDL in attainment of water quality standards.

The monitoring stations will be maintained by DEQ throughout the TMDL implementation process. DEQ and DCR will continue to use data from these stations for evaluating reductions in fecal bacteria counts and the effectiveness of the TMDL in attainment of water quality standards.

The monitoring frequency for fecal coliform bacteria will be two or more samples within a 30-day-period. This sampling frequency is needed to provide fecal coliform counts to evaluate and verify that the TMDL will attain and maintain, not exceeding a geometric mean of 200 fecal coliform bacteria per 100 mL over a 30 day-period. A special study will be done when deemed necessary and resources will be available to further document water quality improvements in the watersheds.

6.2 TMDL Implementation Process

The goal of this TMDL is to establish a pathway that will lead to expeditious attainment of water quality standards. The first step in this process was to develop a TMDL that can be achieved with reasonable assurance. The second step is to develop a TMDL implementation plan, and the final step is to implement the TMDL.

Section 303(d) of the Clean Water Act and EPA’s 303(d) regulation do not provide new implementing mechanisms for TMDL development. However, Virginia’s 1997 Water Quality Monitoring, Information and Restoration Act directs DEQ to develop a plan for the expeditious implementation of TMDLs.

DEQ plans to incorporate TMDL implementation plans as part of the 303(e) Water Quality Management Plans (WQMP). In response to the recent EPA / DEQ Memorandum of Understanding, DEQ submitted a Continuous Planning Process to EPA in which Virginia commits to updating the WQMPs, which will be the repository of TMDLs and the implementation plans. Each implementation plan will contain a reasonable assurance section that will detail the availability of funds for implementation of voluntary actions. One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. In response to the federal Clean Water Action Plan, Virginia developed a Unified Watershed Assessment that identifies watershed priorities. Watershed restoration activities, such as TMDL implementation, within these priority watersheds are eligible for Section 319 funding. Section 319 funds have been approved to establish an expanded monitoring study and to develop a staged implementation plan to meet the water quality goals identified in the TMDL.

6.2.1 Staged Implementation Plan

In order to avoid over-implementation, in the modeling uncertainties or the applicable water quality standard changes (fecal coliform standard is currently under review by DEQ), implementation of best management practices (BMPs) in the watersheds will occur in stages. Various BMPs based on fecal coliform sources contributing to the water quality impairment, as identified in the TMDL, will be targeted for implementation—both agricultural and urban. Targeting is proposed to ensure optimum utilization of funds, and to support a staged implementation approach which will include measurable goals and milestones to evaluate the predictability of the model and the effectiveness of control measures. BMPs that are proposed will be modeled to link in-stream water quality conditions with upstream land activities.

Monitoring will be a component of the implementation plan and will include fecal typing and fecal coliform enumerations. Objectives of the monitoring will include: 1) target on-the-ground BMPs for their optimum effectiveness, 2) provide a methodology for determining if measurable goals and milestones are met, and 3) provide a feedback loop for triggering a revision of the TMDL implementation plan(s).

Watershed stakeholders will have opportunities to provide input and participate in development of the implementation plan, with support from regional and local offices of VADEQ, VADCR, Virginia Department of Health (VDH), and other participating assistance agencies. Current regulations of the Virginia Department of Health require correction of all straight pipes and failed septic systems, and it is recommended that all such sources be brought into compliance.

The TMDL implementation goal will be to reduce the existing fecal coliform loads to the watersheds to result in 0 percent violations of the 200 fecal coliform bacteria counts per 100 mL, geometric mean standard. Using the model developed to represent existing conditions; an allocation scenario was developed for each watershed that would result in 0 percent violations of the geometric mean. The model was run for a representative hydrologic year.

The allocation scenarios that are shown in Section 5 reflect the fact that the reduction of direct sources of fecal coliform deposition into the streams and elimination of failed septic systems are critical to reducing the violation of the geometric mean standard, especially during low-flow conditions. Reduction of sources (e.g., overgrazed pasture) that contribute to stormwater runoff transporting fecal coliform bacteria to streams during storm events is less critical. Significant efforts already have been conducted in the watersheds to reduce pollution during storm events. The allocations require no reduction in existing fecal coliform loads from land uses within the Cedar Creek and Hall/Byers Creek watersheds and only a minimal reduction on improved pasture and hayfield in Hutton Creek. Inputs from failing septic systems and other uncontrolled discharges are completely eliminated. High levels of reduction are also needed from cattle in the streams to meet the geometric mean standard.

6.3 Public Participation

The first public meeting was held in Glade Spring on November 9, 1999 to discuss the development of the TMDL, about 28 people attended. Copies of the presentation materials and diagrams outlining the development of the TMDL were available for public distribution. A public meeting notice was published in the *Washington County News* on October 27, 1999 and the *Virginia Register* on November 8, 1999. The public comment period ended on December 7, 1999. No written public comments were received.

The second public meeting was held in Glade Spring on January 27, 2000 to discuss the hydrologic calibration and input data for the TMDL, about 21 people attended. Copies of the presentation materials from the previous meeting were available for public distribution. A public meeting notice was published in the *Virginia Register* on December 28, 1999, the *Washington County News* on January 19, 2000, and the *Bristol Herald Courier* on January 23, 2000. The public comment period ended on February 25, 2000. No written public comments were received.

The third public meeting was held in Glade Spring on March 30, 2000, to discuss the draft TMDL. Copies of the draft TMDL were available for public distribution. A public meeting notice was published in the *Virginia Register* on March 13, 2000, and in local newspapers. The public comment period ended on April 11, 2000.

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The citizens that attended the public meetings and provided comments

Appendix A
Summary of Stream Geometry

Appendix A

TABLE A-1
Summary of Stream Reach Geometry
Middle Fork Holston River TMDLs

Stream	Reach ID	Length (ft)	Depth (ft)	Width (ft)	Mannings	Long. Slope	Side Slope of Upper Flood Plain	Side slope of lower flood plain	Zero-Slope Flood Plain Width (ft)	Side Slope of the Channel
Cedar Cr.	432 0.00	9601	1.857	3.659	0.05	0.0152	2	40	15	0.439
Cedar Cr.	433 0.00	7488	1.870	3.712	0.05	0.0152	2	40	15	0.439
Cedar Cr.	434 0.00	5721	1.868	3.703	0.05	0.0182	2	40	15	0.439
Cedar Cr.	435 0.00	8163	1.500	2.500	0.05	0.0152	2	40	15	0.167
Cedar Cr.	66 0.00	11577	4.000	10.400	0.05	0.0102	2	40	15	0.300
Cedar Cr.	66 1.58	8116	2.395	6.086	0.05	0.0092	2	40	15	0.363
Cedar Cr.	66 3.10	4286	1.916	3.896	0.05	0.0152	2	40	15	0.435
Cedar Cr.	66 3.68	2587	1.822	3.520	0.05	0.0273	2	40	15	0.441
Cedar Cr.	66 2.70	2891	2.090	4.635	0.05	0.0071	2	40	15	0.417
Hall/Byers Cr.	424 0.00	2616	5.000	15.000	0.05	0.0056	2	40	15	0.300
Hall/Byers Cr.	424 0.50	1980	4.074	17.610	0.05	0.0111	2	40	15	0.465
Hall/Byers Cr.	424 0.87	14422	3.000	8.000	0.05	0.0204	2	40	15	0.833
Hall/Byers Cr.	425 0.00	14780	4.000	30.000	0.05	0.0086	2	40	15	1.875
Hall/Byers Cr.	425 2.87	3582	2.242	5.332	0.05	0.0045	2	40	15	0.394
Hall/Byers Cr.	425 2.79	381	2.479	6.517	0.05	0.0111	2	40	15	0.343
Hall/Byers Cr.	425 3.55	15175	2.086	4.615	0.05	0.0204	2	40	15	0.418
Hall/Byers Cr.	426 0.00	16615	2.049	4.455	0.05	0.0204	2	40	15	0.423
Hall/Byers Cr.	427 0.00	2656	1.964	4.090	0.05	0.0152	2	40	15	0.431

TABLE A-1
Summary of Stream Reach Geometry
Middle Fork Holston River TMDLs

Stream	Reach ID	Length (ft)	Depth (ft)	Width (ft)	Mannings	Long. Slope	Side Slope of Upper Flood Plain	Side slope of lower flood plain	Zero-Slope Flood Plain Width (ft)	Side Slope of the Channel
Hall/Byers Cr.	427 0.50	8980	1.841	3.596	0.05	0.0278	2	40	15	0.440
Hall/Byers Cr.	428 0.00	6200	1.864	3.685	0.05	0.0152	2	40	15	0.439
Hall/Byers Cr.	429 0.00	9018	1.872	3.717	0.05	0.0152	2	40	15	0.438
Hall/Byers Cr.	430 0.00	15256	2.000	4.000	0.05	0.0180	2	40	15	0.500
Hutton Cr.	419 0.98	6268	1.831	3.556	0.05	0.0424	2	40	15	0.441
Hutton Cr.	419 0.00	5229	1.887	3.778	0.05	0.0180	2	40	15	0.437
Hutton Cr.	420 0.00	2803	1.831	3.556	0.05	0.0353	2	40	15	0.441
Hutton Cr.	421 0.00	9166	1.821	3.519	0.05	0.0410	2	40	15	0.441
Hutton Cr.	422 0.00	21198	2.152	4.913	0.05	0.0204	2	40	15	0.409
Hutton Cr.	75 0.08	13066	3.630	13.978	0.05	0.0056	2	40	15	0.159
Hutton Cr.	75 2.33	2960	2.078	4.580	0.05	0.0087	2	40	15	0.419
Hutton Cr.	75 2.18	926	2.517	6.724	0.05	0.0087	2	40	15	0.333
Hutton Cr.	75 2.81	8345	1.961	4.079	0.05	0.0364	2	40	15	0.432

Appendix B
Summary of Septic Failure Date–1988

Appendix B

TABLE B-1
Summary of Septic Failure Data - 1988

Subwatershed ID	Stream	# Septic Failures	Flow from Septic Failure (cfs)	Load from Septic Failures (counts/hour)
432_0.00	Cedar Cr.	0.4	0.000048	488,706
433_0.00	Cedar Cr.	0.4	0.000048	488,706
435_0.00	Cedar Cr.	1.2	0.000144	1,466,119
66_0.00	Cedar Cr.	2.3	0.000269	2,744,274
66_1.58	Cedar Cr.	3.2	0.000372	3,796,872
66_2.70	Cedar Cr.	1.0	0.000111	1,127,784
66_3.10	Cedar Cr.	1.6	0.000188	1,917,232
424_0.00	Hall/Byers Cr.	0.3	0.000041	413,521
424_0.50	Hall/Byers Cr.	0.2	0.000018	187,964
424_0.87	Hall/Byers Cr.	5.9	0.000682	6,954,666
425_0.00	Hall/Byers Cr.	1.9	0.000217	2,217,975
425_2.87	Hall/Byers Cr.	0.6	0.000066	676,670
425_3.55	Hall/Byers Cr.	1.9	0.000225	2,293,160
426_0.00	Hall/Byers Cr.	2.6	0.000306	3,120,201
427_0.00	Hall/Byers Cr.	0.4	0.000048	488,706
427_0.50	Hall/Byers Cr.	0.1	0.000015	150,371
428_0.00	Hall/Byers Cr.	0.0	0.000004	37,593
429_0.00	Hall/Byers Cr.	0.7	0.000081	827,041
430_0.00	Hall/Byers Cr.	3.0	0.000350	3,571,315
419_0.00	Hutton Cr.	2.1	0.000247	2,518,717
421_0.00	Hutton Cr.	0.4	0.000048	488,706
422_0.00	Hutton Cr.	3.2	0.000372	3,796,872
75_0.08	Hutton Cr.	2.3	0.000262	2,669,088
75_2.18	Hutton Cr.	0.6	0.000074	751,856
75_2.81	Hutton Cr.	3.1	0.000361	3,684,093

TABLE B-2
Summary of Septic Failure Data - 1999

Subwatershed ID	Stream	# Septic Failures	Flow from Septic Failure (cfs)	Load from Septic Failures (counts/hour)
432_0.00	Cedar Cr.	0.5	0.000053	539,163
433_0.00	Cedar Cr.	0.5	0.000053	539,163
435_0.00	Cedar Cr.	1.4	0.000159	1,617,490
66_0.00	Cedar Cr.	2.6	0.000297	3,027,610
66_1.58	Cedar Cr.	3.5	0.000411	4,188,885
66_2.70	Cedar Cr.	1.1	0.000122	1,244,223
66_3.10	Cedar Cr.	0.8	0.000094	953,904
424_0.00	Hall/Byers Cr.	0.4	0.000045	456,215
424_0.50	Hall/Byers Cr.	0.2	0.000020	207,371
424_0.87	Hall/Byers Cr.	5.4	0.000622	6,345,539
425_0.00	Hall/Byers Cr.	1.6	0.000183	1,866,335
425_2.87	Hall/Byers Cr.	0.6	0.000073	746,534
425_3.55	Hall/Byers Cr.	1.4	0.000163	1,658,964
426_0.00	Hall/Byers Cr.	2.5	0.000285	2,903,188
427_0.00	Hall/Byers Cr.	0.5	0.000053	539,163
427_0.50	Hall/Byers Cr.	0.1	0.000016	165,896
428_0.00	Hall/Byers Cr.	0.0	0.000004	41,474
429_0.00	Hall/Byers Cr.	0.8	0.000089	912,430
430_0.00	Hall/Byers Cr.	3.3	0.000386	3,940,040
419_0.00	Hutton Cr.	2.3	0.000272	2,778,765
421_0.00	Hutton Cr.	0.5	0.000053	539,163
422_0.00	Hutton Cr.	3.5	0.000411	4,188,885
75_0.08	Hutton Cr.	2.5	0.000289	2,944,662
75_2.18	Hutton Cr.	0.7	0.000081	829,482
75_2.81	Hutton Cr.	3.4	0.000398	4,064,463

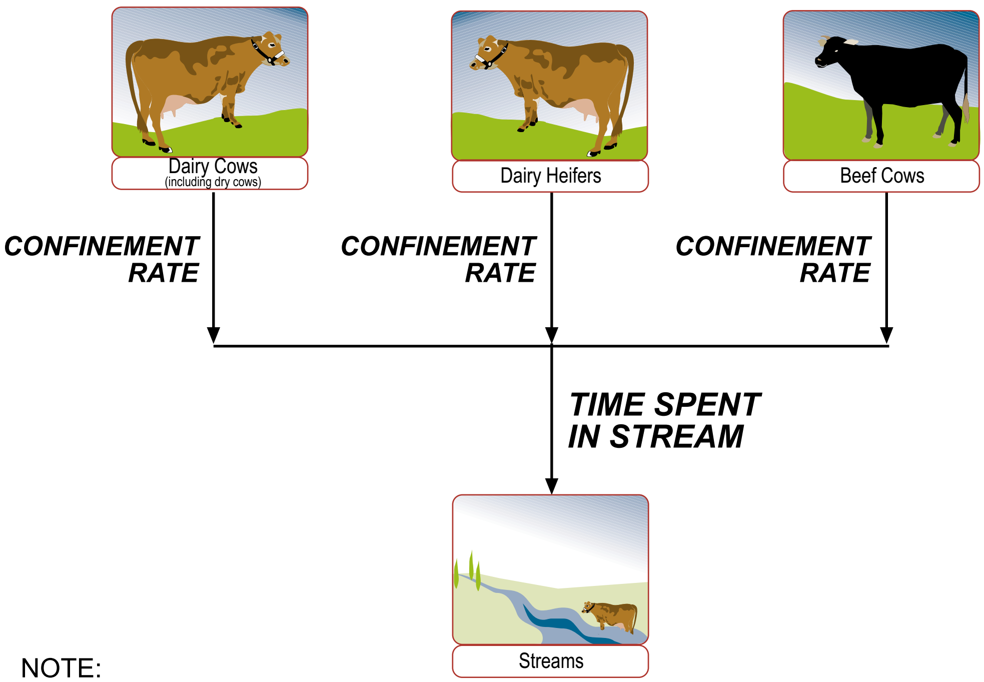
TABLE B-3
Summary of Septic Failure Data - 2010

Subwatershed ID	Stream	# Septic Failures	Flow from Septic Failure (cfs)	Load from Septic Failures (counts/hour)
432_0.00	Cedar Cr.	0.5	0.000056	572,271
433_0.00	Cedar Cr.	0.5	0.000056	572,271
435_0.00	Cedar Cr.	1.5	0.000168	1,716,814
66_0.00	Cedar Cr.	2.7	0.000315	3,213,523
66_1.58	Cedar Cr.	3.8	0.000436	4,446,107
66_2.70	Cedar Cr.	1.1	0.000129	1,320,626
66_3.10	Cedar Cr.	0.9	0.000099	1,012,480
424_0.00	Hall/Byers Cr.	0.4	0.000047	484,230
424_0.50	Hall/Byers Cr.	0.2	0.000022	220,104
424_0.87	Hall/Byers Cr.	5.7	0.000660	6,735,192
425_0.00	Hall/Byers Cr.	1.7	0.000194	1,980,939
425_2.87	Hall/Byers Cr.	0.7	0.000078	792,376
425_3.55	Hall/Byers Cr.	1.5	0.000173	1,760,835
426_0.00	Hall/Byers Cr.	2.6	0.000302	3,081,461
427_0.00	Hall/Byers Cr.	0.5	0.000056	572,271
427_0.50	Hall/Byers Cr.	0.1	0.000017	176,083
428_0.00	Hall/Byers Cr.	0.0	0.000004	44,021
429_0.00	Hall/Byers Cr.	0.8	0.000095	968,459
430_0.00	Hall/Byers Cr.	3.5	0.000410	4,181,982
419_0.00	Hutton Cr.	2.5	0.000289	2,949,398
421_0.00	Hutton Cr.	0.5	0.000056	572,271
422_0.00	Hutton Cr.	3.8	0.000436	4,446,107
75_0.08	Hutton Cr.	2.6	0.000306	3,125,481
75_2.18	Hutton Cr.	0.7	0.000086	880,417
75_2.81	Hutton Cr.	3.6	0.000423	4,314,045

Appendix C
Fecal Coliform Accumulation Rate Development

Fecal Coliform Accumulation Rate Development

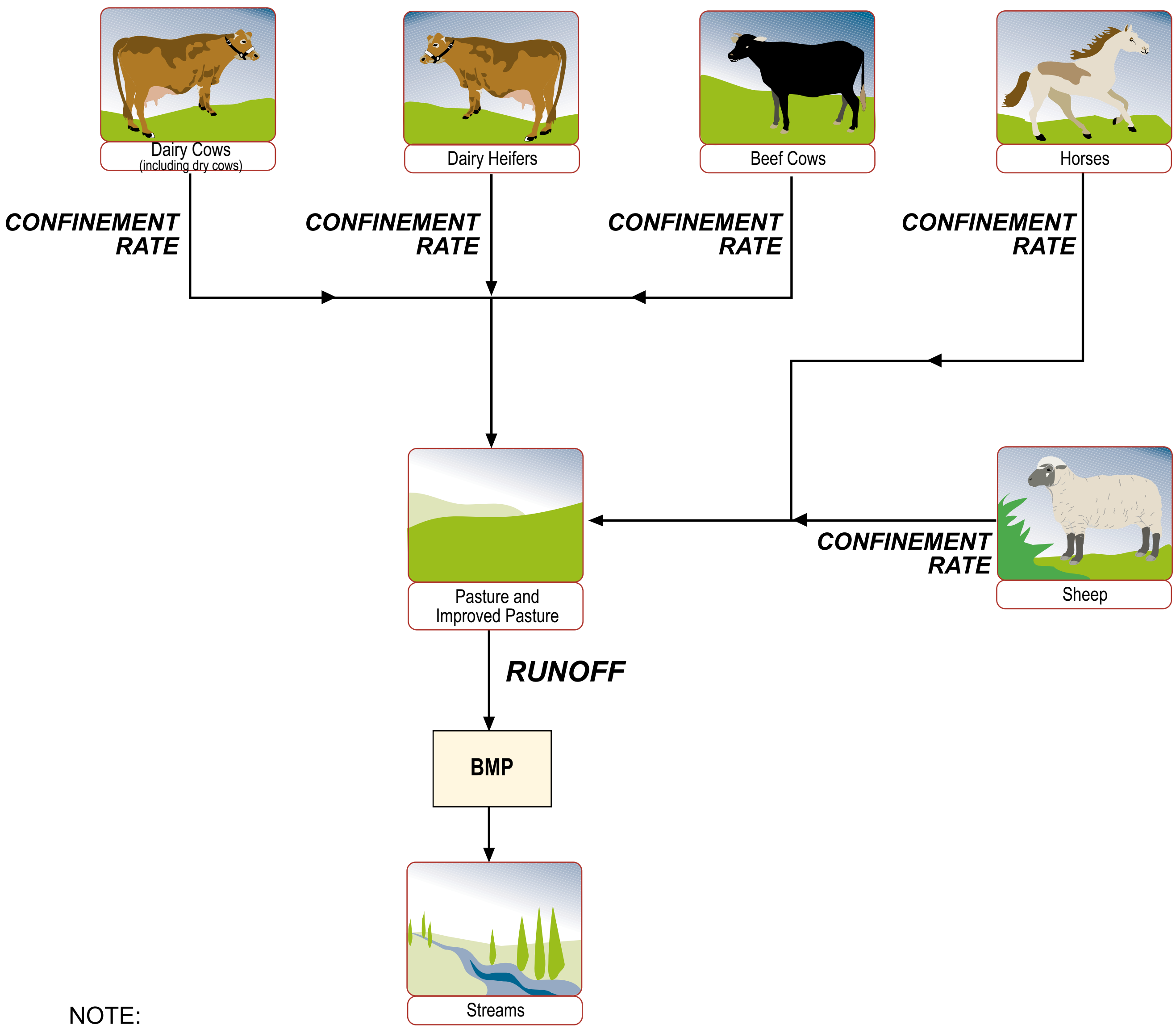
Source: Cattle Contribution Directly Deposited Instream



NOTE:
Confinement rates
vary monthly

Fecal Coliform Accumulation Rate Development

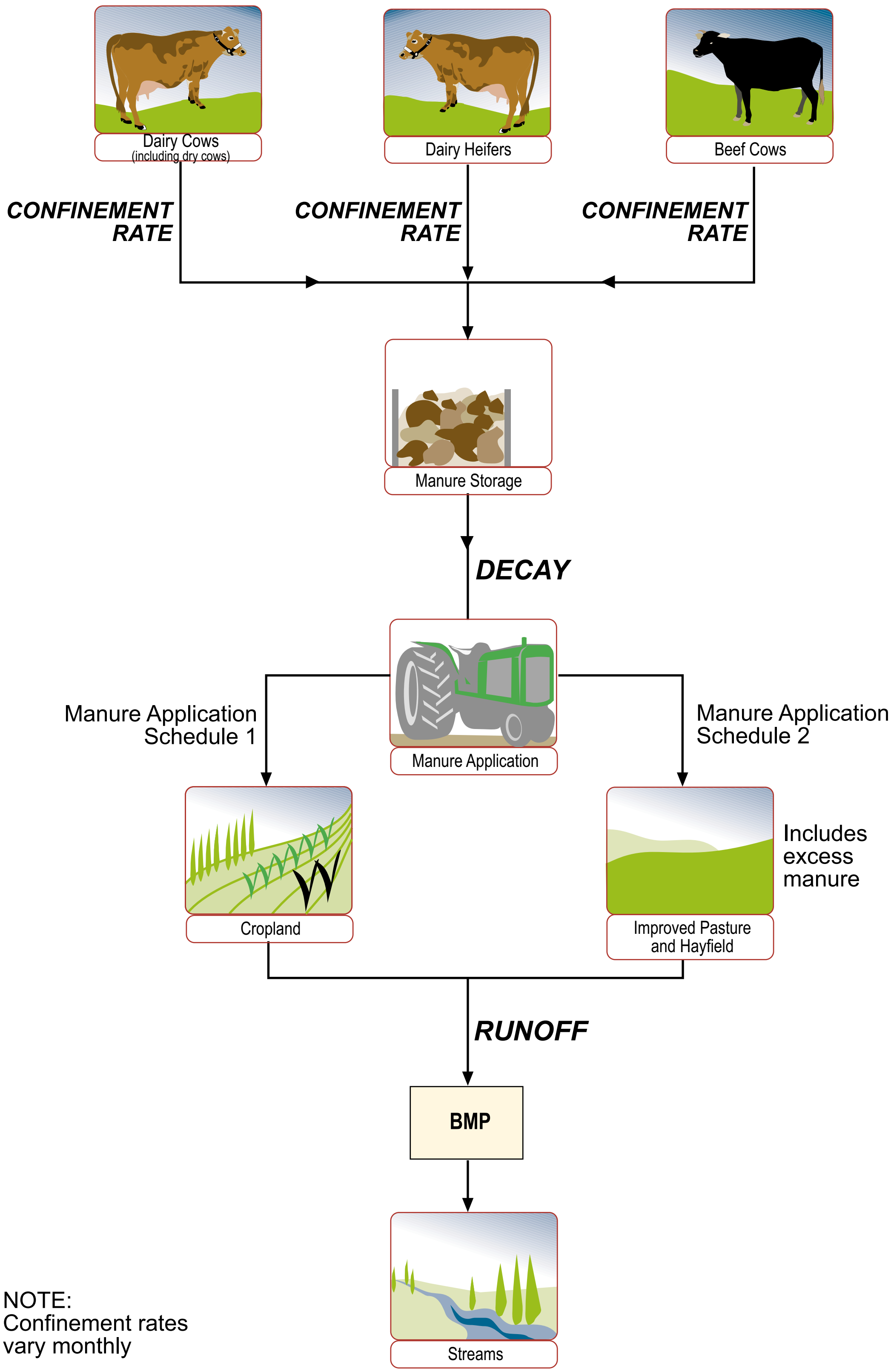
Source: Grazing Livestock (Improved Pasture, Overgrazed Pasture, and Poor Pasture)



NOTE:
Confinement rates
vary monthly

Fecal Coliform Accumulation Rate Development

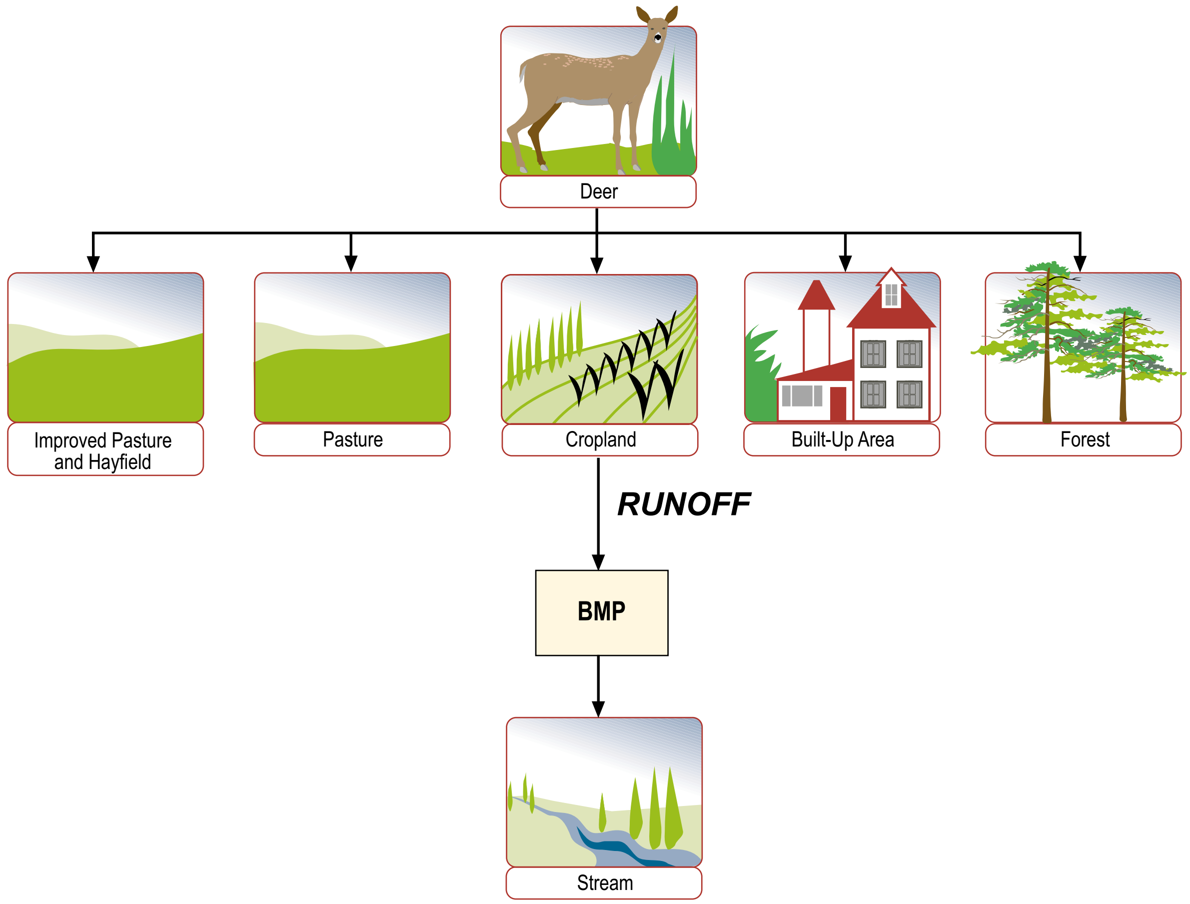
Source: Manure Application



NOTE:
Confinement rates
vary monthly

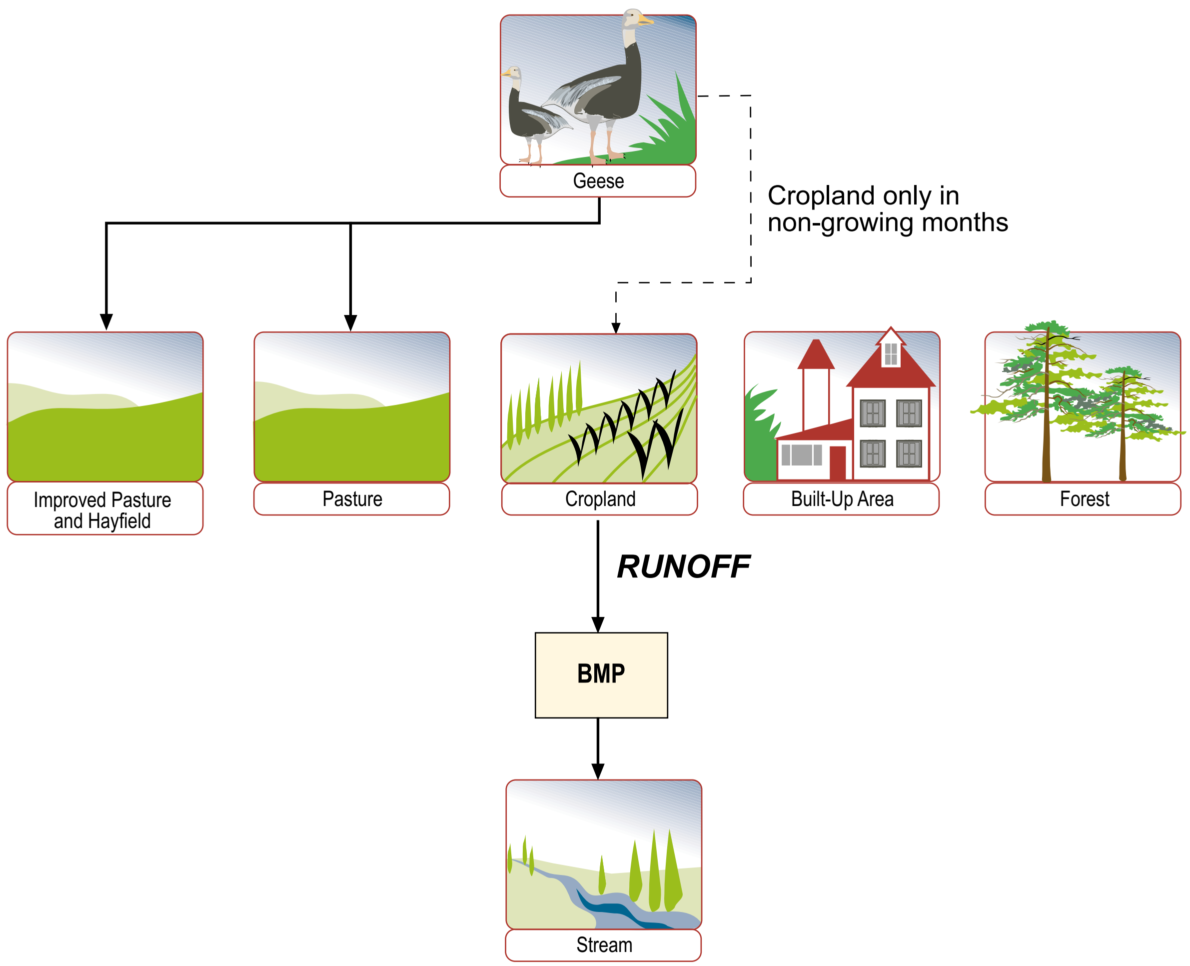
Fecal Coliform Accumulation Rate Development

Source: Deer



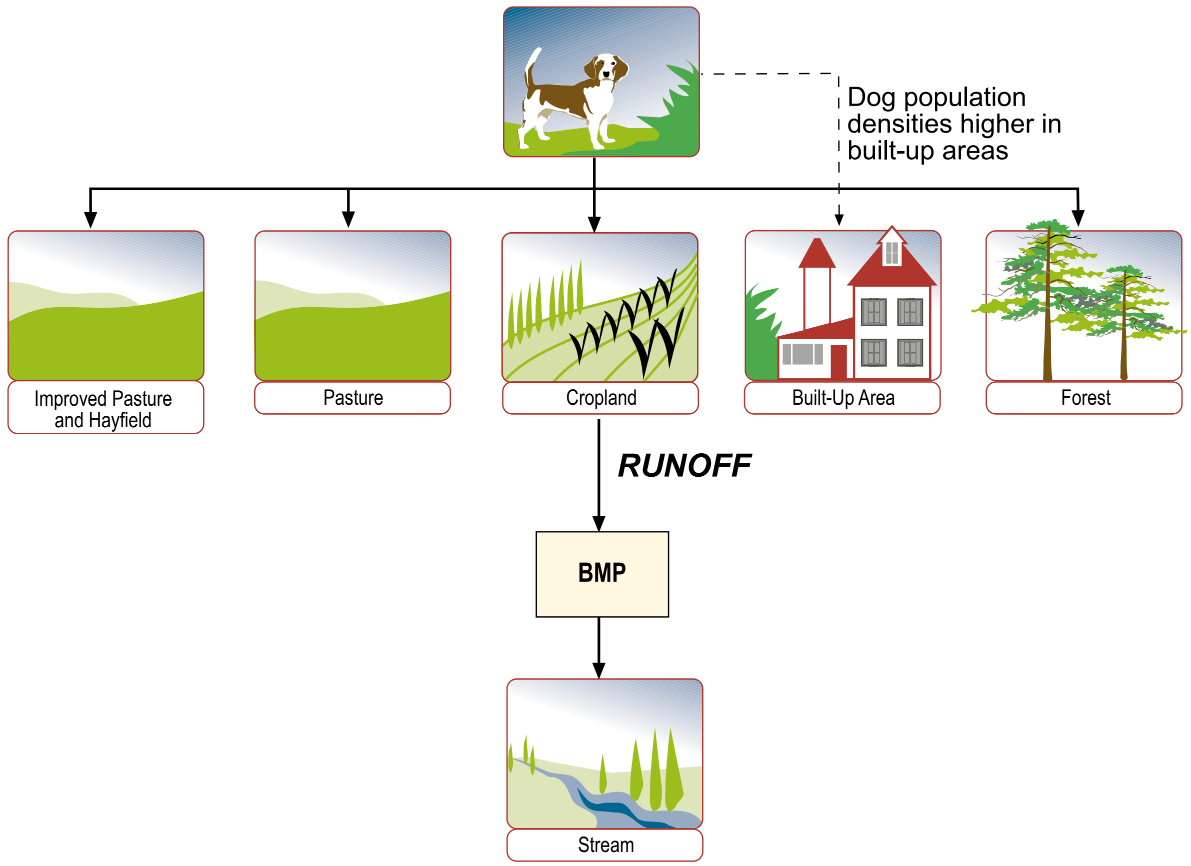
Fecal Coliform Accumulation Rate Development

Source: Geese



Fecal Coliform Accumulation Rate Development

Source: Dogs



Appendix D
Addendum—Response to EPA's Questions

This addendum includes responses to EPA's Questions on the Middle Fork Holston Report.

1. *EPA's comment: Please provide a flow chart for all of these waters, documenting the flow from the mouth of the Middle Fork Holston.*

EXHIBIT D-1
Flow Chart of Cedar Creek Stream Network

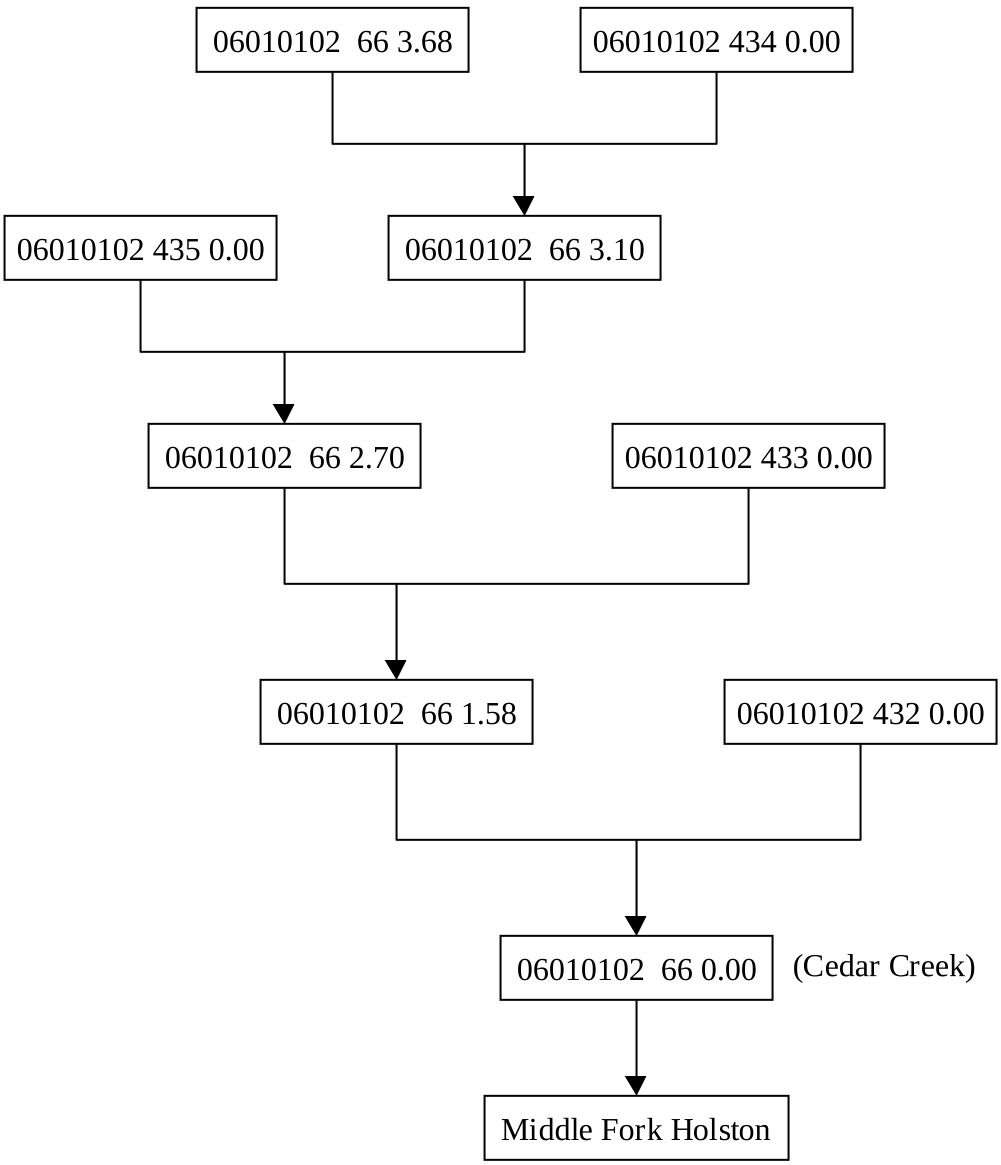


EXHIBIT D-2
Flow Chart of Hall/Byers Creek Stream Network (Reach ID's)

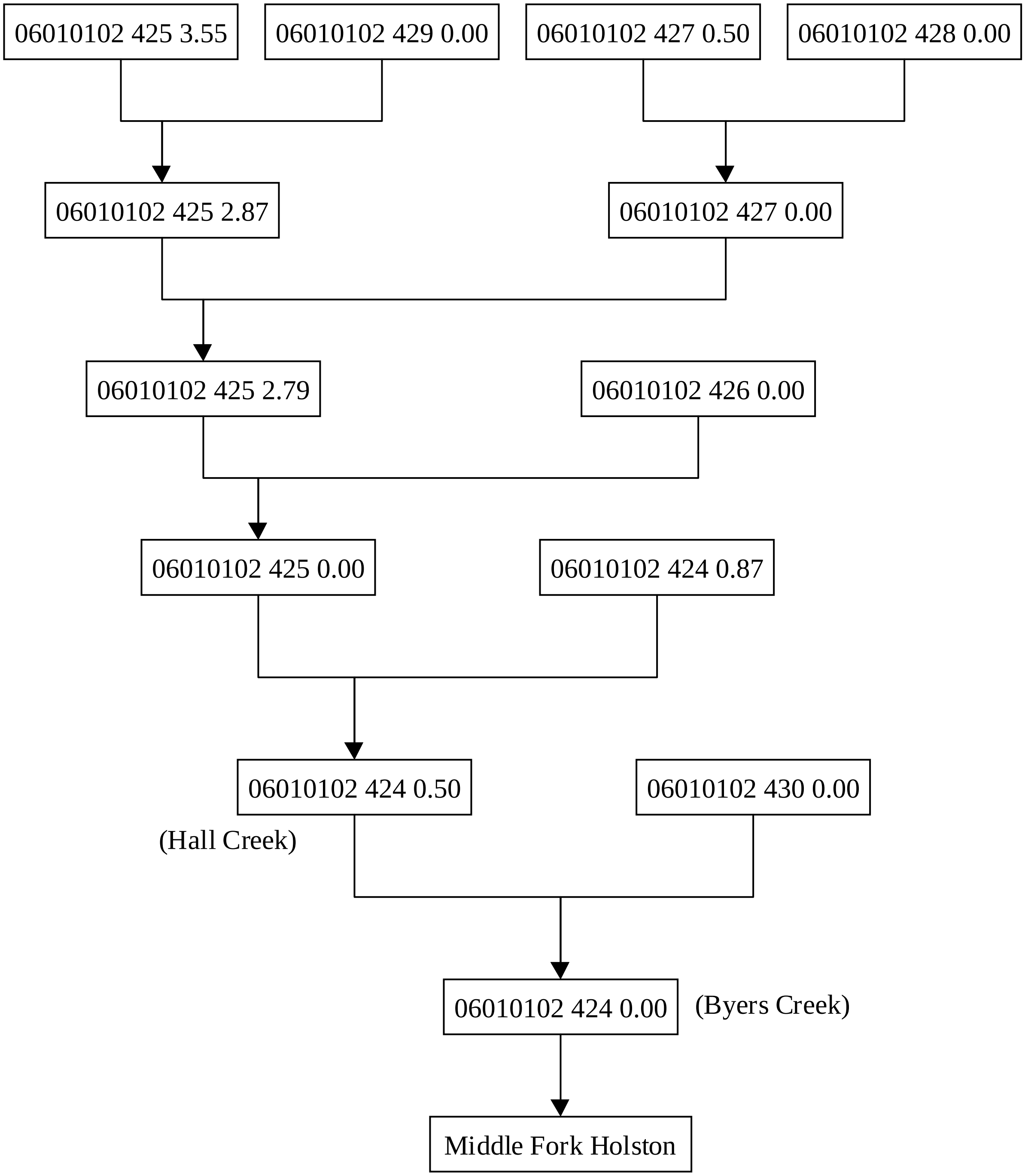
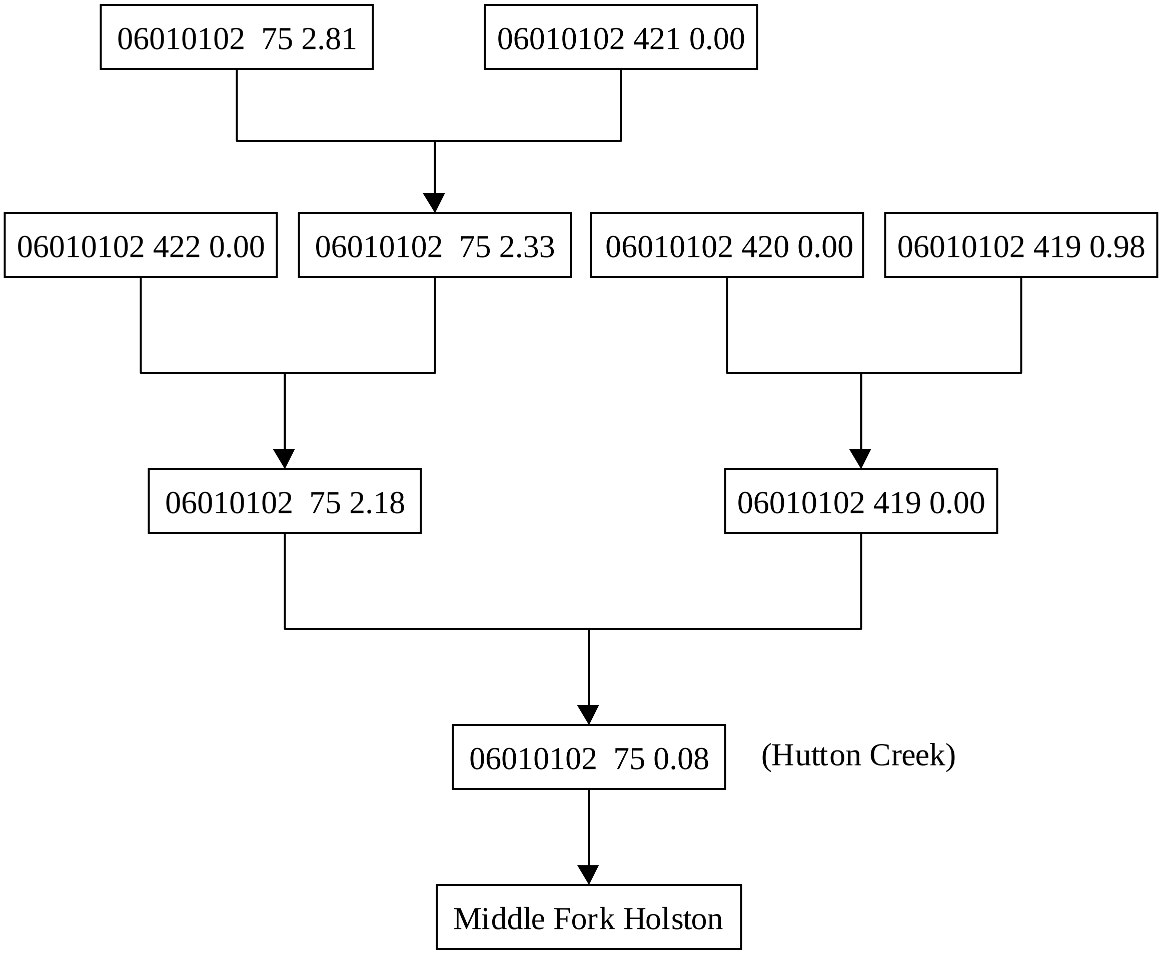


EXHIBIT D-3
Flow Chart of Hutton Creek Stream Network (Reach ID's)



2. *EPA's comment: Please provide EPA with the number of subwatersheds for each stream and the land uses for each of these areas.*

TABLE D-1
Land Use Distribution for Hutton Creek Subwatersheds Under Existing Land Use Condition (1999)

Subwatershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
1	Forest	3.27	160.14	163.41
(06010102 421 0.00)	Improved Pasture	0.98	48.26	49.24
	Overgrazed Pasture	0.68	33.08	33.76
	Poor Pasture	0.01	0.25	0.26
	Row Crop	0.07	3.32	3.38
2	Built-up Area	16.11	48.34	64.46
(06010102 75 2.81)				
	Forest	11.03	540.31	551.34
	Improved Pasture	3.19	156.31	159.50
	Overgrazed Pasture	2.81	137.84	140.65
	Poor Pasture	0.12	5.80	5.91
	Row Crop	1.32	64.68	66.00
3	Built-up Area	126.19	378.56	504.75
(06010102 422 0.00)	Forest	5.07	248.33	253.40
	Improved Pasture	5.94	290.87	296.80
	Overgrazed Pasture	9.02	441.89	450.91
	Poor Pasture	2.21	108.07	110.27
	Row Crop	4.46	218.30	222.75
	Strip Crop	1.59	77.94	79.54
4	Built-up Area	40.27	120.81	161.08
(06010102 75 0.08)	Forest	2.79	136.89	139.68
	Hayfield	1.20	58.73	59.93
	Improved Pasture	4.13	202.40	206.53
	Overgrazed Pasture	25.61	1254.83	1280.44
	Poor Pasture	7.57	370.74	378.31
	Row Crop	3.09	151.32	154.41
	Strip Crop	1.12	55.11	56.23

TABLE D-1
Land Use Distribution for Hutton Creek Subwatersheds Under Existing Land Use Condition (1999)

Subwatershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
5	Forest	1.70	83.08	84.78
(06010102 420 0.00)	Improved Pasture	0.53	26.01	26.54
	Overgrazed Pasture	0.60	29.58	30.19
	Poor Pasture	0.00	0.01	0.01
	Row Crop	0.07	3.34	3.40
6	Forest	1.54	75.52	77.06
(06010102 419 0.00)	Improved Pasture	0.90	43.98	44.88
	Overgrazed Pasture	5.03	246.71	251.74
	Poor Pasture	3.17	155.22	158.39
	Row Crop	0.67	32.74	33.41
	Strip Crop	0.32	15.57	15.89
7	Built-up Area	0.00	0.00	0.00
(06010102 419 0.98)	Forest	6.03	295.28	301.31
	Improved Pasture	2.53	123.91	126.44
	Overgrazed Pasture	0.91	44.35	45.26
	Poor Pasture	0.09	4.53	4.62
	Row Crop	0.11	5.26	5.36
8	Forest	0.25	12.35	12.60
(06010102 75 2.18)	Improved Pasture	0.01	0.31	0.32
	Poor Pasture	0.05	2.68	2.74
9	Built-up Area	0.01	0.02	0.02
(06010102 75 2.33)	Forest	1.42	69.67	71.09
	Hayfield	0.27	13.16	13.43
	Improved Pasture	1.02	50.12	51.14
	Overgrazed Pasture	2.60	127.44	130.04
	Poor Pasture	0.20	9.59	9.78
	Row Crop	0.59	29.00	29.59
	Strip Crop	0.16	7.85	8.01
Total		**310.59**	**6820.38**	**7130.97**

TABLE D-2
Land Use Distribution for Hutton Creek Subwatersheds Under Existing Historic Condition

Watershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
1	Forest	3.24	159.00	162.25
(06010102 421 0.00)	Improved Pasture	0.98	48.26	49.24
	Overgrazed Pasture	0.68	33.08	33.76
	Poor Pasture	0.01	0.25	0.25
	Row Crop	0.07	3.31	3.38
2	Built-up Area	16.11	48.34	64.46
(06010102 75 2.81)	Forest	11.07	542.43	553.50
	Improved Pasture	3.19	156.30	159.49
	Overgrazed Pasture	2.00	98.21	100.21
	Poor Pasture	0.93	45.45	46.37
	Row Crop	1.32	64.68	66.00
3	Built-up Area	126.19	378.56	504.74
(06010102 422 0.00)	Forest	4.77	233.93	238.70
	Improved Pasture	5.94	290.95	296.89
	Overgrazed Pasture	9.03	442.38	451.41
	Poor Pasture	2.21	108.07	110.28
	Row Crop	4.78	234.00	238.78
	Strip Crop	1.59	77.94	79.53
4	Built-up Area	44.58	133.74	178.31
(06010102 75 0.08)	Field Crop	0.75	36.99	37.74
	Forest	2.81	137.86	140.67
	Hayfield	1.21	59.35	60.56
	Improved Pasture	2.89	141.62	144.51
	Overgrazed Pasture	26.62	1304.23	1330.85
	Poor Pasture	7.01	343.41	350.42
	Row Crop	3.67	179.69	183.35
	Strip Crop	0.37	18.12	18.49

TABLE D-2
Land Use Distribution for Hutton Creek Subwatersheds Under Existing Historic Condition

Watershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
5	Forest	1.70	83.08	84.77
(06010102 420 0.00)	Improved Pasture	0.53	26.01	26.54
	Overgrazed Pasture	0.60	29.58	30.19
	Poor Pasture	0.00	0.01	0.01
	Row Crop	0.07	3.34	3.41
6	Forest	1.51	73.96	75.47
(06010102 419 0.00)	Improved Pasture	0.90	43.98	44.87
	Overgrazed Pasture	4.59	224.88	229.47
	Poor Pasture	3.65	178.70	182.34
	Row Crop	0.68	33.13	33.80
	Strip Crop	0.32	15.57	15.89
7	Built-up Area	0.01	0.02	0.02
(06010102 419 0.98)	Forest	6.06	296.84	302.90
	Improved Pasture	2.55	125.06	127.61
	Overgrazed Pasture	0.91	44.35	45.26
	Poor Pasture	0.09	4.64	4.73
	Row Crop	0.11	5.28	5.39
8	Improved Pasture	0.01	0.31	0.32
(06010102 75 2.18)	Poor Pasture	0.31	15.03	15.34
9	Built-up Area	0.01	0.02	0.02
(06010102 75 2.33)				
	Forest	1.31	64.41	65.73
	Hayfield	0.27	13.16	13.43
	Improved Pasture	1.02	50.12	51.14
	Overgrazed Pasture	2.33	114.01	116.34
	Poor Pasture	0.58	28.27	28.85
	Row Crop	0.59	29.00	29.59
	Strip Crop	0.16	7.85	8.01
Total		**314.85**	**6830.72**	**7145.56**

TABLE D-3
Distribution of Land Uses for Hall/Byers Creek Subwatershed Under Existing Condition.

Subwatershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
1	Built-up Area	3.80	11.39	15.19
(06010102 426 0.00)	Forest	7.66	375.13	382.79
	Improved Pasture	8.52	417.41	425.93
	Overgrazed Pasture	6.08	298.10	304.18
	Poor Pasture	3.24	158.80	162.04
	Row Crop	2.18	106.76	108.94
	Strip Crop	0.59	28.94	29.53
2	Forest	4.89	239.47	244.36
(06010102 427 0.50)	Improved Pasture	0.22	10.74	10.96
	Overgrazed Pasture	1.65	80.99	82.64
	Row Crop	0.43	21.04	21.47
3	Forest	4.06	198.96	203.02
(06010102 428 0.00)	Improved Pasture	0.07	3.48	3.55
	Overgrazed Pasture	4.62	226.41	231.03
	Row Crop	0.88	43.13	44.01
4	Built-up Area	59.67	179.01	238.67
(06010102 425 3.55)	Forest	8.63	422.86	431.49
	Improved Pasture	12.98	636.12	649.10
	Overgrazed Pasture	1.23	60.04	61.27
	Poor Pasture	0.77	37.75	38.52
	Row Crop	1.85	90.56	92.40
	Strip Crop	1.81	88.66	90.47
5	Built-up Area	19.98	59.95	79.94
(06010102 429 0.00)	Forest	5.32	260.56	265.88
	Improved Pasture	2.89	141.61	144.50
	Overgrazed Pasture	0.33	16.19	16.52
	Poor Pasture	0.30	14.71	15.01
	Row Crop	0.04	1.85	1.89

TABLE D-3
Distribution of Land Uses for Hall/Byers Creek Subwatershed Under Existing Condition.

Subwatershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
6	Built-up Area	89.24	267.73	356.97
(06010102 424 0.87)	Forest	3.91	191.59	195.50
	Hayfield	1.39	68.18	69.57
	Improved Pasture	11.45	561.13	572.58
	Overgrazed Pasture	8.02	392.83	400.84
	Poor Pasture	2.61	127.95	130.56
	Row Crop	3.02	147.79	150.81
	Strip Crop	1.38	67.70	69.08
7	Built-up Area	7.71	23.14	30.85
(06010102 425 2.87)	Forest	0.26	12.89	13.15
	Hayfield	0.14	6.84	6.98
	Improved Pasture	1.56	76.65	78.22
	Overgrazed Pasture	0.76	37.40	38.16
	Row Crop	0.60	29.52	30.12
8	Built-up Area	115.50	346.51	462.02
(06010102 425 0.00)	Forest	3.35	164.29	167.65
	Hayfield	0.06	2.71	2.77
	Improved Pasture	5.08	248.92	253.99
	Overgrazed Pasture	7.38	361.54	368.92
	Poor Pasture	0.96	47.16	48.13
	Row Crop	1.64	80.15	81.79
9	Built-up Area	20.57	61.70	82.27
(06010102 430 0.00)	Field Crop	0.28	13.90	14.19
	Forest	2.86	140.24	143.10
	Hayfield	0.30	14.79	15.09
	Improved Pasture	8.03	393.30	401.33
	Overgrazed Pasture	8.45	414.25	422.70
	Poor Pasture	3.13	153.35	156.48
	Row Crop	2.04	100.18	102.23
	Strip Crop	0.60	29.34	29.94

TABLE D-3
Distribution of Land Uses for Hall/Byers Creek Subwatershed Under Existing Condition.

Subwatershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
10	Forest	0.59	28.93	29.52
(06010102 424 0.50)	Improved Pasture	1.26	61.86	63.12
	Overgrazed Pasture	2.19	107.19	109.38
	Row Crop	0.02	0.99	1.01
11	Forest	1.03	50.24	51.27
(06010102 424 0.00)	Improved Pasture	2.29	112.00	114.28
	Overgrazed Pasture	2.00	97.95	99.95
	Poor Pasture	0.72	35.11	35.82
	Row Crop	0.31	15.08	15.39
12	Forest	0.01	0.48	0.49
(06010102 425 2.79)	Improved Pasture	0.00	0.15	0.16
	Overgrazed Pasture	0.00	0.15	0.16
	Poor Pasture	0.00	0.12	0.12
13	Built-up Area	0.24	0.71	0.95
(06010102 427 0.00)				
	Forest	0.40	19.63	20.03
	Improved Pasture	1.03	50.60	51.63
	Overgrazed Pasture	1.62	79.26	80.87
	Row Crop	0.16	7.77	7.93
Total		**490.84**	**9482.52**	**9973.37**

TABLE D-4
Land Use Distribution for Hall/Byers Creek Subwatersheds Under Historic Condition

Watershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
1	Built-up Area	3.80	11.39	15.18
(06010102 426 0.00)	Forest	6.14	301.07	307.22
	Improved Pasture	8.52	417.59	426.12
	Overgrazed Pasture	7.58	371.34	378.91
	Poor Pasture	2.27	111.07	113.34
	Row Crop	3.21	157.34	160.55
	Strip Crop	0.59	28.94	29.53
2	Forest	4.65	227.67	232.32
(06010102 427 0.50)	Improved Pasture	0.47	23.14	23.61
	Overgrazed Pasture	1.65	80.99	82.65
	Row Crop	0.43	21.04	21.47
3	Forest	3.98	195.09	199.07
(06010102 428 0.00)	Improved Pasture	0.15	7.36	7.51
	Overgrazed Pasture	4.62	226.39	231.01
	Row Crop	0.88	43.14	44.02
4	Built-up Area	59.67	179.00	238.67
(06010102 425 3.55)	Forest	8.35	409.31	417.66
	Improved Pasture	13.36	654.70	668.06
	Overgrazed Pasture	2.00	97.77	99.76
	Row Crop	3.66	179.57	183.24
5	Built-up Area	19.99	59.96	79.94
(06010102 429 0.00)	Forest	5.16	253.01	258.18
	Improved Pasture	3.06	150.04	153.10
	Overgrazed Pasture	0.63	30.90	31.53
	Row Crop	0.04	1.85	1.89

TABLE D-4
Land Use Distribution for Hall/Byers Creek Subwatersheds Under Historic Condition

Watershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
6	Built-up Area	44.37	133.11	177.48
(06010102 424 0.87)	Forest	3.64	178.14	181.78
	Hayfield	1.39	68.18	69.57
	Improved Pasture	11.83	579.57	591.40
	Overgrazed Pasture	9.53	466.95	476.48
	Poor Pasture	2.80	136.99	139.79
	Row Crop	6.30	308.48	314.77
7	Built-up Area	7.71	23.14	30.86
(06010102 425 2.87)	Forest	0.11	5.56	5.67
	Hayfield	0.14	6.84	6.98
	Improved Pasture	1.71	83.98	85.69
	Overgrazed Pasture	0.76	37.40	38.17
	Row Crop	0.60	29.52	30.12
8	Built-up Area	23.47	70.40	93.87
(06010102 425 0.00)	Field Crop	0.14	6.91	7.05
	Forest	4.95	242.64	247.59
	Hayfield	0.06	2.71	2.77
	Improved Pasture	6.10	299.10	305.21
	Overgrazed Pasture	9.96	487.85	497.80
	Poor Pasture	0.82	39.99	40.80
	Row Crop	3.80	186.37	190.17
9	Built-up Area	20.57	61.70	82.27
(06010102 430 0.00)	Field Crop	0.28	13.90	14.19
	Forest	2.86	140.23	143.09
	Hayfield	0.30	14.79	15.09
	Improved Pasture	8.03	393.58	401.61
	Overgrazed Pasture	8.45	414.29	422.75
	Poor Pasture	1.75	85.66	87.41
	Row Crop	3.43	168.04	171.47
	Strip Crop	0.60	29.35	29.95

TABLE D-4
Land Use Distribution for Hall/Byers Creek Subwatersheds Under Historic Condition

Watershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
10	Forest	0.59	28.93	29.52
(06010102 424 0.50)	Improved Pasture	1.26	61.86	63.12
	Overgrazed Pasture	2.19	107.19	109.38
	Row Crop	0.02	0.99	1.01
11	Forest	1.03	50.48	51.51
(06010102 424 0.00)	Improved Pasture	2.31	112.97	115.28
	Overgrazed Pasture	2.02	98.90	100.91
	Poor Pasture	0.72	35.12	35.84
	Row Crop	0.31	15.32	15.63
12	Forest	0.01	0.48	0.49
(06010102 425 2.79)	Improved Pasture	0.00	0.15	0.16
	Overgrazed Pasture	0.00	0.15	0.16
	Poor Pasture	0.00	0.12	0.12
13	Built-up Area	0.24	0.71	0.95
(06010102 427 0.00)	Forest	0.12	6.03	6.15
	Improved Pasture	1.03	50.60	51.63
	Overgrazed Pasture	1.62	79.26	80.87
	Row Crop	0.44	21.37	21.81
Total		**365.24**	**9625.68**	**9990.92**

TABLE D-5
Land Use Distribution for Cedar Creek Subwatersheds Under Existing Condition.

Subwatershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
1	Built-up Area	23.64	70.92	94.55
(06010102 433 0.00)	Field Crop	0.07	3.28	3.35
	Forest	0.50	24.68	25.18
	Hayfield	0.17	8.48	8.65
	Improved Pasture	2.21	108.10	110.30
	Overgrazed Pasture	2.43	119.09	121.52
	Poor Pasture	0.48	23.70	24.18
	Row Crop	0.56	27.68	28.24
	Strip Crop	2.04	100.19	102.23
2	Built-up Area	33.07	99.20	132.26
(06010102 66 1.58)	Field Crop	0.11	5.39	5.50
	Forest	1.06	51.94	53.00
	Hayfield	0.09	4.23	4.32
	Improved Pasture	4.09	200.54	204.64
	Overgrazed Pasture	5.49	269.17	274.66
	Poor Pasture	0.77	37.78	38.55
	Row Crop	0.66	32.19	32.85
	Strip Crop	1.95	95.38	97.32
3	Built-up Area	10.66	31.99	42.65
(06010102 435 0.00)	Forest	0.87	42.65	43.52
	Hayfield	0.15	7.46	7.61
	Improved Pasture	3.75	183.84	187.59
	Overgrazed Pasture	3.90	191.24	195.14
	Poor Pasture	1.06	51.85	52.90
	Row Crop	0.60	29.60	30.20

TABLE D-5
Land Use Distribution for Cedar Creek Subwatersheds Under Existing Condition.

Subwatershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
4	Built-up Area	9.10	27.30	36.40
(06010102 66 2.70)	Field Crop	0.05	2.26	2.31
	Forest	0.33	15.97	16.30
	Improved Pasture	1.53	75.18	76.71
	Overgrazed Pasture	1.69	82.96	84.65
	Poor Pasture	0.16	7.96	8.12
	Row Crop	1.13	55.52	56.65
	Strip Crop	0.16	7.84	8.00
5	Forest	0.58	28.66	29.25
(06010102 432 0.00)	Hayfield	0.26	12.68	12.94
	Improved Pasture	3.02	148.09	151.11
	Overgrazed Pasture	1.05	51.61	52.66
	Poor Pasture	1.89	92.43	94.31
	Row Crop	0.02	0.89	0.91
	Strip Crop	2.11	103.30	105.40
6	Forest	4.69	229.72	234.40
(06010102 66 0.00)	Improved Pasture	7.79	381.55	389.34
	Overgrazed Pasture	5.05	247.42	252.47
	Poor Pasture	4.76	233.02	237.77
	Row Crop	0.95	46.75	47.70
	Strip Crop	0.46	22.32	22.78
7	Built-up Area	38.19	114.58	152.77
(06010102 434 0.00)	Disturbed Area	0.06	3.15	3.22
	Forest	0.69	33.83	34.52
	Improved Pasture	0.70	34.14	34.83
	Poor Pasture	0.03	1.23	1.25
	Row Crop	0.60	29.41	30.01
	Strip Crop	2.72	133.26	135.98

TABLE D-5
Land Use Distribution for Cedar Creek Subwatersheds Under Existing Condition.

Subwatershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
8	Built-up Area	9.95	29.84	39.78
(06010102 66 3.68)	Field Crop	0.11	5.25	5.36
	Hayfield	0.04	2.20	2.25
	Improved Pasture	0.76	37.26	38.02
	Overgrazed Pasture	0.81	39.55	40.35
	Row Crop	0.63	30.71	31.34
	Strip Crop	0.08	3.97	4.05
9	Built-up Area	14.46	43.37	57.83
(06010102 66 3.10)	Forest	0.97	47.32	48.28
	Improved Pasture	1.42	69.47	70.89
	Overgrazed Pasture	0.27	13.35	13.62
	Row Crop	0.14	6.95	7.09
	Strip Crop	0.12	6.02	6.15
Total		**219.91**	**4378.81**	**4598.72**

TABLE D-6
Land Use Distribution for Cedar Creek Subwatersheds Under Historic Condition.

Subwatershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
1	Built-up Area	7.75	23.25	31.00
(06010102 433 0.00)	Forest	0.49	23.99	24.48
	Hayfield	0.17	8.48	8.65
	Improved Pasture	4.57	223.81	228.38
	Overgrazed Pasture	2.79	136.80	139.59
	Poor Pasture	0.48	23.70	24.19
	Row Crop	1.24	60.69	61.93
2	Built-up Area	31.28	93.83	125.10
(06010102 66 1.58)	Field Crop	0.11	5.39	5.50
	Forest	0.59	28.83	29.41
	Hayfield	0.09	4.23	4.31
	Improved Pasture	4.43	216.87	221.30
	Overgrazed Pasture	6.11	299.56	305.67
	Poor Pasture	0.42	20.46	20.88
	Row Crop	2.63	128.91	131.54
3	Built-up Area	10.66	31.99	42.65
(06010102 435 0.00)	Forest	1.06	52.15	53.22
	Hayfield	0.15	7.46	7.61
	Improved Pasture	3.89	190.57	194.45
	Overgrazed Pasture	3.93	192.61	196.54
	Poor Pasture	1.07	52.53	53.60
	Row Crop	0.61	29.98	30.60
4	Built-up Area	9.10	27.30	36.40
(06010102 66 2.70)	Field Crop	0.16	7.66	7.82
	Forest	0.33	16.18	16.51
	Improved Pasture	1.54	75.35	76.89
	Overgrazed Pasture	1.70	83.19	84.89
	Poor Pasture	0.16	7.96	8.13
	Row Crop	1.19	58.27	59.46

TABLE D-6
Land Use Distribution for Cedar Creek Subwatersheds Under Historic Condition.

Subwatershed-ID	Land Use Name	Impervious Area (acres)	Pervious Area (acres)	Total Area (acres)
5	Forest	0.58	28.66	29.25
(06010102 432 0.00)	Hayfield	0.26	12.68	12.94
	Improved Pasture	3.02	148.08	151.10
	Overgrazed Pasture	1.05	51.60	52.66
	Poor Pasture	0.10	5.10	5.21
	Row Crop	3.43	168.24	171.67
	Strip Crop	0.48	23.28	23.76
6	Forest	2.81	137.73	140.54
(06010102 66 0.00)	Improved Pasture	8.92	437.02	445.94
	Overgrazed Pasture	5.45	267.16	272.61
	Poor Pasture	2.40	117.59	119.99
	Row Crop	4.25	208.39	212.64
7	Built-up Area	38.19	114.58	152.77
(06010102 434 0.00)	Disturbed Area	0.06	3.15	3.22
	Field Crop	0.01	0.51	0.52
	Forest	0.69	33.83	34.52
	Improved Pasture	3.42	167.58	171.00
	Poor Pasture	0.03	1.23	1.26
	Row Crop	0.60	29.51	30.11
8	Built-up Area	9.94	29.83	39.78
(06010102 66 3.68)	Hayfield	0.04	2.20	2.25
	Improved Pasture	0.85	41.56	42.41
	Overgrazed Pasture	0.81	39.85	40.67
	Row Crop	0.74	36.21	36.95
9	Built-up Area	14.46	43.37	57.83
(06010102 66 3.10)	Field Crop	0.12	6.02	6.15
	Forest	0.97	47.32	48.29
	Improved Pasture	1.42	69.47	70.89
	Overgrazed Pasture	0.27	13.35	13.62
	Row Crop	0.14	6.95	7.09
Total		**204.24**	**4424.09**	**4628.33**

3. *EPA's comment: In section 3.3.2, it is mentioned that the average rainfall for the area was 43 inches per year (based on the Prism model). Section 4.8.1, states that the average rainfall for the study area was 38 inches. Please explain the difference in precipitation data.*

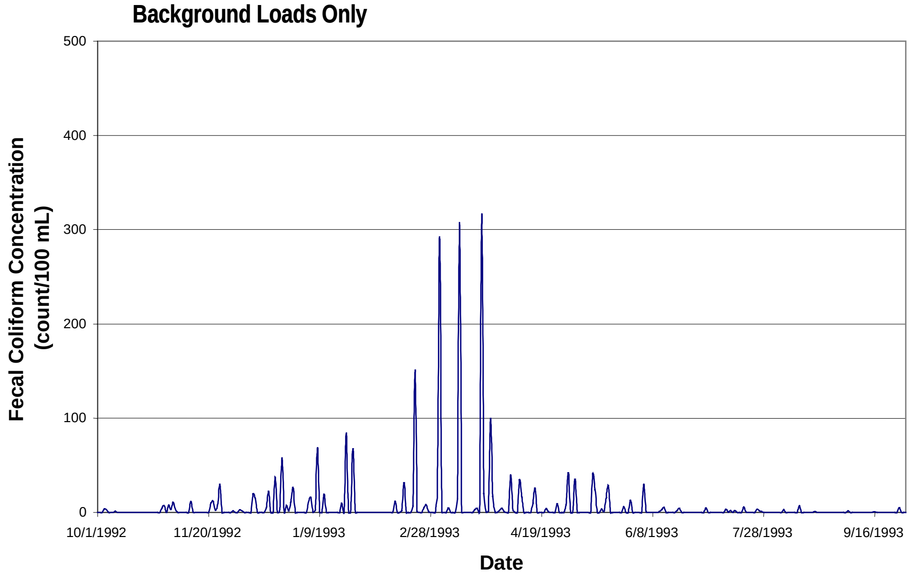
PRISM (Parameter-elevation Regressions on Independent Slopes Model) is an expert system that uses point data and a digital elevation model (DEM) to generate gridded estimates of climate parameters (Daly et al., 1994). According to PRISM, the annual precipitation in the study area is 43 inches. PRISM data was used only to select appropriate meteorological stations for modeling. Once the stations were selected, actual hourly precipitation data from the selected stations was used for modeling. The precipitation time series, developed using the arithmetic mean method (Section 3.3.2), showed an average 38 inches of annual rainfall based on 1987-1998 data.

4. *EPA's comment: One of the requirements of a TMDL is the consideration of background pollutant contributions. In section 5.4.1, there is a brief statement regarding what was considered background contamination. Please elaborate on this discussion and include all the components of background loading, the numeric load associated with background conditions, and how background loading was applied.*

Background loads were explicitly modeled in all simulation runs by considering background sources in computing fecal coliform accumulation rates on different land uses. Sources considered in modeling background loads (accumulation rate of 4.4 x 108 counts/acres/day) include deer population in all areas at a density as specified in Section 3.5.4 (30 deer/sq. mile) and 200 geese in the watershed.

In one instance, the model was setup for Cedar Creek assuming that deer and geese were the only sources of fecal coliform on every land use (alternately the whole watershed was covered by forest) and all other sources of nonpoint and point sources were turned off in the model to simulate the impact of background loads on instream water quality. The model results (Exhibit D-4) showed no violation of water quality standards.

EXHIBIT D-4
Cedar Creek, Fecal Coliform Concentrations (count/100 mL) Under Background Loads Only



5. *EPA's comment: The consideration of a critical condition is another requirement of the TMDL. In the report it is stated that the critical condition is a typical hydrologic year because bacteria reaches these segments as a result of both dry and wet weather deposition. Please elaborate on why there were no reductions needed for land applied wastes if the above condition is valid.*

According to the final allocation scenarios (Section 5.2.2), there is no need for reduction in fecal coliform load for land applied waste to meet the water quality standard in Cedar and Hall/Byers Creek watersheds. In the Hutton Creek watershed 10 percent reduction in land applied waste on improved pasture and hayfield is needed to meet the water quality standard. Many agricultural BMPs were already implemented in the Cedar Creek, Hall/Byers Creek, and Hutton Creek watersheds and a 12 to 15.6 percent reduction in fecal coliform loads were already obtained as shown by the model. The model also showed that any further reduction in fecal coliform load to meet the water quality standard can be best achieved by reducing the load from direct deposition to the streams. Additionally, the 30-day geometric mean fecal coliform concentration includes the contribution from different sources under both dry and wet conditions, and, as stated in Section 5.2.2, different combinations of scenarios were evaluated prior to selecting the final allocation scenario.

6. *EPA's comment: During high flow events, are the elevated concentrations of fecal coliform associated with nonpoint sources or the resuspension of fecal coliform laden sediments.*

Fecal coliform was not modeled as a sediment associated pollutant. Therefore, there was no explicit consideration of resuspension in the model. During high flow events sources of fecal coliform were both nonpoint and point sources.

7. *EPA's comment: Based on the sampling data from December of 1999, the Meadowview Elementary School is discharging fecal coliform at concentrations greater than their permit allows. What is being done to address this situation?*

Table 3-12 lists the results of fecal coliform samples collected at the active point sources on December 8 and 9, 1999. The effluent from the Meadowview Elementary School had a fecal coliform bacteria count of 1,700 counts/100 mL. Elevated counts of this magnitude are usually not found in a properly operating disinfection unit. DEQ will verify the operation of the disinfection units at the Medowview Elementary sewage treatment plant to ensure that the treated discharge is not contributing to the fecal coliform standard violation in the Cedar Creek watershed. In modeling the fecal coliform count in the stream, the effluent from the school was assumed to be equivalent to the geometric mean water quality standard of 200 counts/100 mL. To assure that the permit condition is being met, DEQ will monitor the effluent on a monthly basis for 6 months. If the additional effluent monitoring shows elevated counts, the problem will be addressed through standard inspections and/or enforcement procedures.

8. *EPA's comment: A die-off rate of 20 percent was used for fecal coliform originating from failed septic tanks. Was this rate used for any other sources of fecal coliform? Please document the die-off rate that was used for the storage of wastes, the deposition of wastes on land, and application of wastes.*

Die-off was not explicitly calculated for fecal coliform originating from failed septic tanks.

Die-off rate for the storage of waste: Decay rate 0.3 day-1 (Walker et al, 1990) and temperature correction coefficient for first order decay as 1.07 (HSPF default).

Die-off rate for the wastes deposited and applied on the land: The decay rate of 0.14 day-1 was assumed for wastes deposited and applied on land surface. The decay rate of 0.14 day-1 translated into the value of model parameter SQOLIM, the maximum surface buildup, as seven times of the daily accumulation rate.

Instream die-off rate (decay rate): 1.152 day-1 (=0.048 hr-1) (USEPA, 1985; Lombardo, 1972) and temperature correction coefficient for first order decay as 1.07 (HSPF default).

9. *EPA's comment: What are the percent reductions in loading to the streams as a result of BMPs and the exact values of post- and pre-BMP loading?*

TABLE D-7
Fecal Coliform Loads (Counts) by Watershed for Pre- and Post-BMP Conditions.

Watershed	Annual Fecal Coliform Load (counts)		Percent Reduction
	Pre-BMP	Post-BMP	
Cedar Creek Watershed	5.89E+14	4.97E+14	15.6%
Hall/Byers Creek Watershed	9.90E+14	8.41E+14	15.1%
Hutton Creek Watershed	1.29E+15	1.13E+15	12.2%

10. *EPA's comment: Surface runoff component from pervious land segments account for less than 1 percent of the flow for Cedar and Hall Creek. EPA derived these values by keying SURO, AGWO, PERO, and IFWO into the output manager and then running the model.*

The surface runoff from pervious land is less than 1 percent for the entire simulation period when the output is generated, as stated by EPA. However, this number does not correctly represent the overall runoff characteristics of the watersheds. Rather it is an oversimplification of the model results. Our findings and justifications are listed below:

A. The BASINS' Nonpoint Source Model (NPSM) only allows users to print total runoff (PERO), surface runoff (SURO), interflow (IFWO), and groundwater (AGWO) contributions from each acre of pervious or impervious (surface runoff only) land of each land use type. NPSM does not allow users to combine the runoff from both pervious and impervious land use, and does not allow users to calculate the area weighted total runoff by watersheds. Therefore, we edited the HSPF input file and ran HSPF in DOS to obtain the desired output.

In the Cedar Creek, Hall Creek, and Hutton Creek models, each land use was divided into pervious and impervious land use types. In contrast, the Muddy Creek model assumed 100 percent pervious for cropland, pasture, and forest. In other words, if there are any impervious areas in these land uses, the Muddy Creek model parameter values—obtained through model calibration—implicitly lumped the effect of both pervious and impervious surfaces. Therefore, the surface runoff from a pervious land use in Cedar Creek, Hall Creek, and Hutton Creek models are not directly comparable to the surface runoff in the Muddy Creek model. Rather the combined surface runoff from pervious and impervious surfaces of each land use type in the Cedar Creek, Hall Creek, and Hutton Creek models should be compared to the surface runoff generated by the Muddy Creek model.

The watershed wide aggregation of surface runoff, interflow, and groundwater flows in a 2-year simulation (October, 1988 through September, 1989 weather data, 1999 watershed conditions) provides the following distributions in the Cedar, Hall, and Hutton Creek Watersheds (see Table D-8).

TABLE D-8
Distribution of Flows Simulated by Cedar Creek, Hall Creek, and Hutton Creek Models

Component of Flow	Cedar Creek	Hall Creek	Hutton Creek
Surface Runoff	15.3%	15.9%	14.3%
Interflow	12%	11.5%	11.7%
Groundwater/Baseflow	72.7%	72.6%	74.0%

B. The percentage of surface runoff from pervious land is 1 percent over long time periods that include both wet weather and dry weather conditions. Since the surface runoff only occurs during a storm event, we printed hourly output and reviewed the model results during a storm event. A large storm, for example, generated surface runoff as high as 38.7 percent of the total from cropland in 1-hour of the storm as shown in Table D-9 below.

TABLE D-9
Distribution of Flow Components During a Storm Event in Cedar Creek

				PERO	SURO		IFWO		AGWO	
Year	Month	Day	Hour	(in)	% of Total	(in)	% of Total	(in)	% of Total	(in)
1988	2	3	18	1.85E-03	0.0%	0	24.5%	4.54E-04	75.5%	1.40E-03
1988	2	3	19	2.02E-03	8.3%	1.68E-04	22.5%	4.55E-04	69.1%	1.40E-03
1988	2	3	20	1.92E-03	0.6%	1.23E-05	26.1%	5.01E-04	73.2%	1.40E-03
1988	2	3	21	2.11E-03	3.5%	7.39E-05	29.4%	6.20E-04	67.1%	1.42E-03
1988	2	3	22	2.47E-03	8.4%	2.08E-04	33.8%	8.35E-04	57.8%	1.43E-03
1988	2	3	23	3.22E-03	20.6%	6.63E-04	34.6%	1.12E-03	44.8%	1.44E-03
1988	2	3	24	3.08E-03	10.0%	3.07E-04	42.6%	1.31E-03	47.4%	1.46E-03
1988	2	4	1	3.51E-03	12.4%	4.37E-04	45.7%	1.61E-03	41.9%	1.47E-03
1988	2	4	2	5.34E-03	33.7%	1.80E-03	38.5%	2.05E-03	27.8%	1.49E-03
1988	2	4	3	5.28E-03	22.7%	1.20E-03	48.8%	2.58E-03	28.4%	1.50E-03
1988	2	4	4	4.64E-03	5.1%	2.37E-04	62.3%	2.89E-03	32.6%	1.51E-03
1988	2	4	5	4.39E-03	0.2%	1.04E-05	65.1%	2.86E-03	34.6%	1.52E-03

TABLE D-9
Distribution of Flow Components During a Storm Event in Cedar Creek

Year	Month	Day	Hour	PERO (in)	SURO % of Total	SURO (in)	IFWO % of Total	IFWO (in)	AGWO % of Total	AGWO (in)
1988	2	4	6	4.48E-03	1.0%	4.42E-05	65.0%	2.91E-03	34.0%	1.52E-03
1988	2	4	7	5.73E-03	15.5%	8.88E-04	57.9%	3.32E-03	26.6%	1.53E-03
1988	2	4	8	8.83E-03	38.7%	3.42E-03	44.6%	3.94E-03	16.7%	1.48E-03
1988	2	4	9	6.92E-03	16.0%	1.11E-03	63.4%	4.39E-03	20.6%	1.43E-03
1988	2	4	10	6.04E-03	1.9%	1.16E-04	74.7%	4.51E-03	23.4%	1.41E-03
1988	2	4	11	5.87E-03	0.0%	0	75.9%	4.45E-03	24.1%	1.42E-03

The distribution of surface runoff, interflow, and baseflow as shown in Table D-9 is reasonable for this type of watershed. A higher percentage of surface runoff during some hours of a prolonged storm event (17 hours) suggests that the model generates adequate surface runoff during a high intensity storm event.

11. *EPA's comment: Fecal coliform concentrations that were used in the model for interflow and groundwater. The unit for IOQC and AOQC is counts/cft, not counts/100 mL.*

In review of the EPA's comments about the partitioning of flow and fecal coliform concentrations used in the model for the interflow and groundwater components, DCR informed CH2M HILL that the unit used in the model for the IOQC and AOQC parameters was incorrect. These values should have been input as counts/cft, not counts/100 mL.

CH2M HILL revised the model inputs for Cedar, Hall/Byers, and Hutton Creek watersheds and used "corrected values" for two model parameters–IOQC (fecal coliform concentration in interflow) and AOQC (fecal coliform concentration in groundwater). The values originally input in the model were 1 and 50 for IOQC and AOQC, respectively, since they were inadvertently input as 1 count/100 mL and 50 counts/100 ml. The corrected values were 283 counts/cft and 5,660 counts/cft for IOQC and AOQC, respectively.

CH2M HILL originally used a high value for the concentration of fecal coliform in interflow (50 counts/100 mL). However, when this value was converted to counts/cft to derive the corrected IOQC value, the interflow concentration was found to be too high to achieve the water quality standard with any reasonable allocation scenario. CH2M HILL, therefore, revisited the fecal coliform data obtained from wells in the Middle Fork Holston River watershed. Distribution of observed fecal coliform concentrations in the wells are provided in Table D-10.

TABLE D-10
Distribution of Observed Fecal Coliform Concentrations in Wells in the Middle Fork Holston River Watershed (Source: STORET).

Fecal Coliform Concentration	Number of Samples
More than 60 counts/100 mL	1
Less than 100 counts/100mL	2
4 counts/100mL	1
3 counts/100mL	1
1 counts/100mL	1
Less than 1 counts/100mL	21

The fecal coliform concentration in one sample was more than 60 counts/100 mL indicating a potentially contaminated well. In two other wells, the observed concentration was less than a detection limit of 100 counts/100 mL. These samples do not provide any valuable information in determining fecal coliform concentrations in ground water and inflow. Therefore, fecal coliform concentrations in interflow and ground water were estimated based on the remaining 24 observations. Since the fecal coliform concentration in the vast majority of the samples was below the detection limit of 1 count/100 mL, the fecal coliform concentration in groundwater (AOQC) was estimated as 0 count/100 mL. Success of sand filters in treating drinking water suggests that water passing through a thick filter media will have bacteria removed completely. For the same reason it is unlikely that there will be any significant presence of bacteria in the interflow. However, CH2M HILL conservatively used 5 counts/100 mL, which is 25 percent more than the maximum observed concentration of 4 counts/100 mL, as the fecal coliform concentration in the interflow (IOQC).

New nonpoint source allocation scenarios, as listed in Tables D-11, D-12, and D-13, were developed to meet the water quality standard (30-day geometric mean of 200 counts/100 mL). These allocation scenarios were based on the corrected fecal coliform concentrations associated with interflow and groundwater. The allocations do not require any reduction of point source loads. Five percent or more of the water quality standard were reserved for margin of safety.

TABLE D-11
Revised Final Allocation Scenario for Cedar Creek

Source	Required Reduction (percent of existing loads or build-up rate)
Cattle in stream	99.3%
Failed septic systems	99.3%

TABLE D-12
Revised Final Allocation Scenario for Hall/Byers Creek

Source	Required Reduction (percent of existing loads or build-up rate)
Cattle in stream	98.4%
Failed septic systems	98.4%

TABLE D-13
Revised Final Allocation Scenario for Hutton Creek

Source	Required Reduction (percent of existing loads or build-up rate)
Cattle in stream	100.0%
Failed septic systems	100.0%
Accumulation on improved pasture, and hayfield	10.0%

It is anticipated that in the implementation of stream fencing to eliminate the direct deposition of fecal matter from cattle in the stream, that the 10 percent reduction in the fecal loading from improved pasture and hayfield will be met without requiring additional management measures. Stream fencing will result in substantial improvements to riparian areas, which will reduce the amount of overland runoff entering the stream. In addition to stream fencing, the installation of alternative watering systems will improve pasture management and the quality of forages. This will further reduce the fecal loading to Hutton Creek from pasture.

Glossary

Allocations. That portion of a receiving water's loading capacity that is attributed to one of its existing or future pollution sources (nonpoint or point) or to natural background sources. (A wasteload allocation [WLA] is that portion of the loading capacity allocated to an existing or future point source, and a load allocation [LA] is that portion allocated to an existing or future nonpoint source or to a natural background source. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading.)

Ambient water quality. Natural concentration of water quality constituents prior to mixing of either point or nonpoint source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact to human health.

Anthropogenic. Pertains to the [environmental] influence of human activities.

Anti-degradation Policies. Policies that are part of each state's water quality standards. These policies are designed to protect water quality and provide a method of assessing activities that may impact the integrity of waterbodies.

Aquatic ecosystem. Complex of biotic and abiotic components of natural waters. The aquatic ecosystem is an ecological unit that includes the physical characteristics (such as flow or velocity and depth), the biological community of the water column and benthos, and the chemical characteristics such as dissolved solids, dissolved oxygen, and nutrients. Both living and nonliving components of the aquatic ecosystem interact and influence the properties and status of each component.

Assimilative capacity. The amount of contaminant load that can be discharged to a specific waterbody without exceeding water quality standards or criteria. Assimilative capacity is used to define the ability of a waterbody to naturally absorb and use a discharged substance without impairing water quality or harming aquatic life.

Background levels. Levels representing the chemical, physical, and biological conditions that would result from natural geomorphological processes such as weathering or dissolution.

BASINS (Better Assessment Science Integrating Point and Nonpoint Sources). A computer-run tool that contains an assessment and planning component that allows users to organize and display geographic information for selected watersheds. It also contains a modeling component to examine impacts of pollutant loadings from point and nonpoint sources and to characterize the overall condition of specific watersheds.

Benthic. Refers to material, especially sediment, at the bottom of an aquatic ecosystem. It can be used to describe the organisms that live on, or in, the bottom of a waterbody.

Benthic organisms. Organisms living in, or on, bottom substrates in aquatic ecosystems.

Best management practices (BMPs). Methods, measures, or practices that are determined to be reasonable and cost-effective means for a land owner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

Bioassessment. Biological assessment; the evaluation of an ecosystem using integrated assessments of habitat and biological communities in comparison to empirically defined reference conditions.

Biological criteria. Also known as biocriteria, biological criteria are narrative expressions or numeric values of the biological characteristics of aquatic communities based on appropriate reference conditions. Biological criteria serve as an index of aquatic community health.

Boundary conditions. Values or functions representing the state of a system at its boundary limits.

Calibration. The process of adjusting model parameters within physically defensible ranges until the resulting predictions give a best possible good fit to observed data.

Channel. A natural stream that conveys water; a ditch or channel excavated for the flow of water.

Channel improvement. The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means in order to increase its capacity. Sometimes used to connote channel stabilization.

Channel stabilization. Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, vegetation, and other measures.

Clean Water Act (CWA). The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33.

U.S.C. 1251 et seq. The CWA contains a number of provisions to restore and maintain the quality of the nation’s water resources. One of these provisions is section 303(d), which establishes the TMDL program.

Completely mixed condition. A condition in which no measurable difference in the concentration of a pollutant exists across a transect of the waterbody (e.g., the concentration does not vary by 5 percent).

Concentration. Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm). Bacteria are usually measured in counts per 100 milliliters (counts/100 mL).

Concentration-based limit. A limit based on the relative strength of a pollutant in a wastestream, usually expressed in milligrams per liter (mg/L).

Conservative substance. A substance that does not undergo any chemical or biological transformation or degradation in a given ecosystem.

Contamination. The act of polluting or making impure; any indication of chemical, sediment, or biological impurities.

Continuous discharge. A discharge that occurs without interruption throughout the operating hours of a facility, except for infrequent shutdowns for maintenance, process changes, or other similar activities.

Conventional pollutants. As specified under the Clean Water Act, conventional contaminants include suspended solids, coliform bacteria, high biochemical oxygen demand, pH, and oil and grease.

Cost-share program. A program that allocates project funds to pay a percentage of the cost of constructing or implementing a best management practice. The remainder of the costs is paid by the producer.

Cross-sectional area. Wet area of a waterbody normal to the longitudinal component of the flow.

Critical condition. The critical condition can be thought of as the “worst case” scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence.

Decay. The gradual decrease in the amount of a given substance in a given system due to various sink processes including chemical and biological transformation, dissipation to other environmental media, or deposition into storage areas.

Decomposition. Metabolic breakdown of organic materials; the formation of by-products of decomposition releases energy and simple organic and inorganic compounds. (Also see, Respiration.)

Design stream flow. The stream flow used to conduct steady-state wasteload allocation modeling.

Designated uses. Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.

Deterministic model. A model that does not include built-in variability: same input will always equal the same output.

Dilution. The addition of some quantity of less concentrated liquid (water) that results in a decrease in the original concentration.

Direct runoff. Water that flows over the ground surface or through the ground directly into streams, rivers, and lakes.

Discharge. Flow of surface water in a stream or canal or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.

Discharge Monitoring Report (DMR). Report of effluent characteristics submitted by a municipal or industrial facility that has been granted an NPDES discharge permit.

Discharge permits (NPDES). A permit issued by the U.S. EPA or a state regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water; it also includes a compliance schedule for achieving those limits. It is called the NPDES because the permit process was established under the National Pollutant Discharge Elimination System, under provisions of the federal Clean Water Act.

Dispersion. The spreading of chemical or biological constituents, including pollutants, in various directions from a point source, at varying velocities depending on the differential in-stream flow characteristics.

Domestic wastewater. Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.

Drainage basin. A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.

Dynamic model. A mathematical formulation describing and simulating the physical behavior of a system or a process and its temporal variability.

Dynamic simulation. Modeling of the behavior of physical, chemical, and / or biological phenomena and their variation over time.

Ecoregion. A physical region that is defined by its ecology, which includes meteorological factors, elevation, plant and animal speciation, landscape position, and soils.

Ecosystem. An interactive system that includes the organisms of a natural community association together with their abiotic physical, chemical, and geochemical environment.

Effluent. Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.

Effluent guidelines. Technical EPA documents that set effluent limitations for given industries and pollutants.

Effluent limitation. Restrictions established by a state or EPA on quantities, rates, and concentrations in pollutant discharges.

Empirical model. Use of statistical techniques to discern patterns or relationships underlying observed or measured data for large sample sets. Does not account for physical dynamics of waterbodies.

Endpoint. An endpoint (or indicator / target) is a characteristic of an ecosystem that may be affected by exposure to a stressor. Assessment endpoints and measurement endpoints are two distinct types of endpoints commonly used by resource managers. An assessment endpoint is the formal expression of a valued environmental characteristic and should have societal relevance (an indicator). A measurement endpoint is the expression of an observed or measured response to a stress or disturbance. It is a measurable environmental characteristic that is related to the valued environmental characteristic chosen as the assessment endpoint. The numeric criteria that are part of traditional water quality standards are good examples of measurement endpoints (targets).

Enhancement. In the context of restoration ecology, it includes any improvement of a structural or functional attribute.

Environmental Monitoring and Assessment Program (EMAP). An EPA program to monitor and assess the ecological health of major ecosystems, including surface waters, forests, near-coastal waters, wetlands, agricultural lands, arid lands, and the Great Lakes, in an integrated, systematic manner. Although EMAP has been curtailed somewhat during recent years, the program is designed to operate at regional and national scales, for decades, and to evaluate the extent and condition of entire ecological resources by using a common sampling framework to sample approximately 12,500 locations in the conterminous United States.

Existing use. Use actually attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).

Fate of pollutants. Involves physical, chemical, and biological transformation in nature and changes to the amount of a pollutant in an environmental system. Transformation processes are pollutant-specific. Because they have comparable kinetics, different formulations for each pollutant are not required.

Feedlot. A confined area for the controlled feeding of animals. Tends to concentrate large amounts of animal waste that cannot be absorbed by the soil and, hence, may be carried to nearby streams or lakes by rainfall runoff.

First-order kinetics. The type of relationship describing a dynamic reaction in which the rate of transformation of a pollutant is proportional to the amount of that pollutant in the environmental system.

Ground water. The supply of fresh water found beneath the earth’s surface, usually in aquifers, which supply wells and springs. Because ground water is a major source of drinking water, there is growing concern over contamination from leaching agricultural or industrial pollutants and leaking underground storage tanks.

Hydrodynamic model. Mathematical formulation used in describing fluid flow circulation, transport, and deposition processes in receiving water.

Hydrograph. A graph showing variation of in stage (depth) or discharge of water in a stream over a period of time.

Hydrologic cycle. The circuit of water movement from the atmosphere to the earth and its return to the atmosphere through various stages or processes, such as precipitation, interception, runoff, infiltration, storage, evaporation, and transpiration.

Hydrology. The study of the distribution, properties, and effects of water on the earth’s surface, in the soil and underlying rocks, and in the atmosphere.

Hyetograph. Graph of rainfall rate during a storm event.

Index of Biotic Integrity (IBI). The IBI uses measurements of the distribution and abundance or absence of several fish species types in each waterbody for comparison. A portion of a waterbody is compared to a similar, unimpacted waterbody in the same ecoregion.

Indicator. A measurable quantity that can be used to evaluate the relationship between pollutant sources and their impact on water quality.

Indirect discharge. A nondomestic discharge introducing pollutants to a publicly owned treatment works.

Infiltration capacity. The capacity of a soil to allow water to infiltrate into or through it during a storm.

Kinetic processes. Description of the rates and modes of changes in the transformation or degradation of a substance in an ecosystem.

Loading, load, loading rate. The total amount of material (pollutants) entering the system from one or multiple sources; measured as a rate in weight per unit time. Bacteria are typically measured as a rate in counts per unit time.

Load allocation (LA). The portion of a receiving waters loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished (40 CFR 130.2(g)).

Loading capacity (LC). The greatest amount of loading that a water can receive without violating water quality standards.

Longitudinal dispersion. The spreading of chemical or biological constituents, including pollutants, downstream from a point source at varying velocities due to the differential in-stream flow characteristics.

Low-flow (7Q10). Low-flow (7Q10) is the 7-day average low flow occurring once in 10 years; this probability-based statistic is used in determining stream design flow conditions and for evaluating the water quality impact of effluent discharge limits.

Margin of Safety (MOS). A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody (CWA section 303(d)(1)(C)). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).

Mass balance. An equation that accounts for the flux of mass going into a defined area and the flux of mass leaving the defined area. The flux in must equal the flux out.

Mass loading. The quantity of a pollutant transported to a waterbody.

Mathematical model. A system of mathematical expressions that describe the spatial and temporal distribution of water quality constituents resulting from fluid transport and the one, or more, individual processes and interactions within some prototype aquatic ecosystem. A mathematical water quality model is used as the basis for waste load allocation evaluations.

Maximum depth. The greatest depth of a waterbody.

Mean depth. Volume of a waterbody divided by its surface area.

Mitigation. Actions taken to avoid, reduce, or compensate for the effects of environmental damage. Among the broad spectrum of possible actions are those that restore, enhance, create, or replace damaged ecosystems.

Monitoring. Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.

Narrative criteria. Nonquantitative guidelines that describe the desired water quality goals.

National Pollutant Discharge Elimination System (NPDES). The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under Sections 307, 402, 318, and 405 of the Clean Water Act.

Natural waters. Flowing water within a physical system that has developed without human intervention, in which natural processes continue to take place.

Nonpoint source. Pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.

Numeric target. A measurable value determined for the pollutant of concern which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.

Numerical model. Model that approximates a solution of governing partial differential equations that describe a natural process. The approximation uses a numerical discretization of the space and time components of the system or process.

One-dimensional model (1-D). A mathematical model defined along one spatial coordinate of a natural water system. Typically, 1-D models are used to describe the longitudinal variation of water quality constituents along the downstream direction of a stream or river. In writing the model, it is assumed that the cross-channel (lateral) and vertical variability is relatively homogenous and can, therefore, be averaged over those spatial coordinates.

Outfall. The point where water flows from a conduit, stream, or drain.

Pathogen. Disease-causing agent, especially microorganisms such as bacteria, protozoa, and viruses.

Peak runoff. The highest value of the stage or discharge attained by a flood or storm event; also referred to as flood peak or peak discharge.

Permit. An authorization, license, or equivalent control document issued by EPA or an approved federal, state, or local agency to implement the requirements of an environmental regulation (e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions).

Permit Compliance System (PCS). Computerized management information system that contains data on NPDES permit-holding facilities. PCS keeps extensive records on more than 65,000 active water-discharge permits on sites located throughout the nation. PCS tracks permit, compliance, and enforcement status of NPDES facilities.

Phased approach. Under the phased approach to TMDL development, LAs and WLAs are calculated using the best available data and information recognizing the need for additional monitoring data to accurately characterize sources and loadings. The phased approach is typically employed when nonpoint sources dominate. It provides for the implementation of load reduction strategies while collecting additional data.

Point source. Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river.

Pollutant. Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water (CWA Section 502(6)).

Pollution. Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, chemical, and radiological integrity of water.

Pool. Portion of a stream with reduced current velocity, often with deeper water than surrounding areas and with a smooth surface.

Public comment period. The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a *Federal Register* notice of a proposed rulemaking, a public notice of a draft permit, or a Notice of Intent to Deny).

Receiving waters. Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.

Reference sites. Waterbodies that are representative of the characteristics of the region and subject to minimal human disturbance.

Reserve capacity. Pollutant loading rate set aside in determining stream waste load allocation accounting for uncertainty and future growth.

Residence time. Length of time that a pollutant remains within a section of a stream or river. The residence time is determined by the streamflow and the volume of the river reach or the average stream velocity and the length of the river reach.

Restoration. Return of an ecosystem to a close approximation of its presumed condition prior to disturbance.

Riparian areas. Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.

Riparian vegetation. Hydrophytic vegetation growing in the immediate vicinity of a lake or river closely enough so that its annual evapotranspiration constitutes a factor in the lake or river regime.

Riparian zone. The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.

Roughness coefficient. A factor in velocity and discharge formulas representing the effects of channel roughness on energy losses in flowing water. Manning's "n" is a commonly used roughness coefficient.

Runoff. That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.

Sedimentation. Process of deposition of waterborne or windborne sediment or other material; also refers to the infilling of bottom substrate in a waterbody by sediment (siltation).

Septic system. An onsite system designed to treat and dispose of domestic sewage. A typical septic system consists of a tank that receives waste from a residence or business and a system of tile lines or a pit for disposal of the liquid effluent (sludge) that remains after decomposition of the solids by bacteria in the tank; must be pumped out periodically.

Sewer. A channel or conduit that carries wastewater and stormwater runoff from the source to a treatment plant or receiving stream. "Sanitary" sewers carry household, industrial, and commercial waste. "Storm" sewers carry runoff from rain or snow. "Combined" sewers handle both.

Sheet erosion. Erosion of the ground surface by unconcentrated (i.e., not in rills) overland flow. (Also see **Sheetwash**.)

Sheetwash. Erosion of the ground surface by unconcentrated (i.e., not in rills) overland flow. (Also see **Sheet erosion**.)

Simulation. The use of mathematical models to approximate the observed behavior of a natural water system in response to a specific known set of input and forcing conditions. Models that have been validated, or verified, are then used to predict the response of a natural water system to changes in the input or forcing conditions.

Slope. The degree of inclination to the horizontal, usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04); degrees (2 degrees 18 minutes), or percent (4 percent).

Steady-state model. Mathematical model of fate and transport that uses constant values of input variables to predict constant values of receiving water quality concentrations.

STORET. U.S. Environmental Protection Agency (EPA) national water quality database for STORage and RETrieval (STORET). Mainframe water quality database that includes physical, chemical, and biological data measured in waterbodies throughout the United States.

Storm runoff. Storm water runoff, snowmelt runoff, and surface runoff and drainage; rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows onto adjacent land or waterbodies or is routed into a drain or sewer system.

Streamflow. Discharge that occurs in a natural channel. Although the term “discharge” can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term streamflow is more general than "runoff" as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

Stream restoration. Various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream due to urbanization, farming, or other disturbance.

Stressor. Any physical, chemical, or biological entity that can induce an adverse response.

Surface area. The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.

Surface runoff. Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.

Surface water. All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.

Temperature coefficient. Rate of increase in an activity or process over a 10 degree Celsius increase in temperature. Also referred to as the Q_{10}.

Three-dimensional model (3-D). Mathematical model defined along three spatial coordinates where the water quality constituents are considered to vary over all three spatial coordinates of length, width, and depth.

Topography. The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.

Total Maximum Daily Load (TMDL). The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.

Transit time. In nutrient cycles, the average time that a substance remains in a particular form; ratio of biomass to productivity.

Transport of pollutants (in water). Transport of pollutants in water involves two main processes: (1) advection, resulting from the flow of water, and (2) diffusion, or transport due to turbulence in the water.

Tributary. A lower order stream compared to a receiving waterbody. "Tributary to" indicates the largest stream into which the reported stream or tributary flows.

Two-dimensional model (2-D). A mathematical model defined along two spatial coordinates where the water quality constituents are considered averaged over the third remaining spatial coordinate. Examples of 2-D models include descriptions of the variability of water quality properties along: (a) the length and width of a river that incorporates vertical averaging of depth, or (b) length and depth of a river that incorporates lateral averaging across the width of the waterbody.

Use Attainability Analysis (UAA). A structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, and economic factors as described in section 131.10(g) (40 CFR 131.3).

Validation (of a model). Process of determining how well the mathematical model's computer representation describes the actual behavior of the physical process under investigation.

Verification (of a model). Testing the accuracy and predictive capabilities of the calibrated model on a data set independent of the data set used for calibration.

Wasteload allocation (WLA). The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation (40 CFR 130.2(h)).

Wastewater. Usually refers to effluent from a sewage treatment plant. See also domestic wastewater.

Wastewater treatment. Chemical, biological, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water in order to remove, reduce, or neutralize contaminants.

Water quality. The biological, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.

Water quality-based effluent limitations. Effluent limitations applied to dischargers when mere technology-based limitations would cause violations of water quality standards. Usually WQBELs are applied to discharges into small streams.

Water quality-based permit. A permit with an effluent limit more stringent than one based on technology performance. Such limits may be necessary to protect the designated use of receiving waters (e.g., recreation, irrigation, industry, or water supply).

Water quality criteria. Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water quality-limited segments. Those water segments which do not or are not expected to meet applicable water quality standards even after the application of technology-based effluent limitations required by sections 301(b) and 306 of the Clean Water Act (40 CFR 130.29(j)). Technology-based controls include, but are not limited to, best practicable control technology currently available (BPT) and secondary treatment.

Water quality standard. Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an anti-degradation statement.

Watershed-based trading. Watershed-based trading is an efficient, market-driven approach that encourages innovation in meeting water quality goals, but remains committed to enforcement and compliance with responsibilities under the Clean Water Act. It involves trading arrangements among point source dischargers, nonpoint sources, and indirect dischargers in which the “buyers” purchase pollutant reductions at a lower cost than what they would spend to achieve the reductions themselves. Sellers provide pollutant reductions and may receive compensation. The total pollution reduction; however, must be the same or greater than what would be achieved if no trade occurred.

Watershed protection approach (WPA). The EPA’s comprehensive approach to managing water resource areas, such as river basins, watersheds, and aquifers. WPA has four major features—targeting priority problems, stakeholder involvement, integrated solutions, and measuring success.

Watershed-scale approach. A consideration of the entire watershed, including the land mass that drains into the aquatic ecosystem.

Watershed. A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Wetland. An area that is saturated by surface water or ground water with vegetation adapted for life under those soil conditions, as in swamps, bogs, fens, marshes, and estuaries.

Addendum to the Report "Fecal Coliform TMDL Development for Cedar, Hall, Byers, and Hutton Creek, Virginia" (January 2001)

In their letter reviewing the fecal coliform TMDLs for four impaired segments in the Middle Fork Holston River basin, EPA made the following comment: *Table 5.6 in the TMDL report lists the average annual loading for all of the Middle Fork Holston TMDLs. It appears as though the Waste Load Allocation (WLA) for Cedar Creek and Hall/Byers Creek are equivalent to the daily loads from the permitted facilities. If the WLA is set as a daily load, kindly amend this value to document the annual loading.*

In response to this comment, tables ES-1 and 5.6 of the TMDL report were adjusted to reflect the waste load allocation for permitted facilities in terms of counts/year as shown below instead of counts/day as in the original report.

TABLE ES-1

Summary of Fecal Coliform TMDL Calculated to Average Annual Loading (counts/year)

Middle Fork Holston River TMDLs

Watershed	TMDL200 [(a)] (counts/year)	WLA [(b)] (counts/year)	LA [(c)] (counts/year)	MOS [(d)] (counts/year)
Cedar Creek	6.07E+14	1.55E+10	5.77E+14	3.04E+13
Hall/Byers Creeks	1.03E+15	7.85E+10	9.83E+14	5.17E+13
Hutton Creek	1.35E+15	0	1.28E+15	6.75E+13

a TMDL200 represents loading that corresponds compliance with the 200 count/100 mL geometric mean standard.

b Daily loads derived from Table 5-1, Waste Load Allocation for Point Sources, adjusted to annual load.

c Summation of load allocations from Table 5-2, Cedar Creek; Table 5-3, Hall/Byers Creeks; Table 5-4, Hutton Creek; Existing and Allocated Fecal Coliform Loads.

d A 5% MOS is used to target load reductions to meet a monthly geometric mean of 190 counts/100 mL (i.e., 5% of the 200 counts/100 mL geometric mean standard). In order to express this MOS explicitly for the purpose of this summary, the loading in this table is calculated based on the equation: TMDL200 = WLA + LA + (0.05 TMDL200).

This equation is used for illustration purposes only since the standard is based on concentrations.

TABLE 5.6
Summary of Fecal Coliform TMDL Calculated to Average Annual Loading (counts/year)
Middle Fork Holston River TMDLs

Watershed	TMDL200 (a) (counts/year)	WLA (b) (counts/year)	LA (c) (counts/year)	MOS (d) (counts/year)
Cedar Creek	6.07E+14	1.55E+10	5.77E+14	3.04E+13
Hall/Byers Creeks	1.03E+15	7.85E+10	9.83E+14	5.17E+13
Hutton Creek	1.35E+15	0	1.28E+15	6.75E+13

a TMDL200 represents loading that corresponds compliance with the 200 count/100 mL geometric mean standard.
b Daily loads derived from Table 5-1, Waste Load Allocation for Point Sources, adjusted to annual load.
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d A 5% MOS is used to target load reductions to meet a monthly geometric mean of 190 counts/100 mL (i.e., 5% of the 200 counts/100 mL geometric mean standard). In order to express this MOS explicitly for the purpose of this summary, the loading in this table is calculated based on the equation: TMDL200 = WLA + LA + (0.05 TMDL200).
This equation is used for illustration purposes only since the standard is based on concentrations.